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Miyashita et al.

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(45) **Date of Patent: Jun. 17, 2008**

(54) **METHOD AND SYSTEM FOR TRANSMITTING DATA IN TWO STEPS BY USING DATA STORAGE PROVIDED IN DATA TRANSMISSION EQUIPMENT IN NETWORK**

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(73) Assignee: **Fujitsu Limited**, Kawasaki (JP)

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(22) Filed: **Apr. 3, 2002**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H04L 12/54 (2006.01)

(52) **U.S. Cl.** **370/428**; 709/229; 711/123

(58) **Field of Classification Search** 370/422, 370/428, 429, 539, 540; 709/203, 211, 216, 709/229, 231, 232; 711/118, 154, 155
See application file for complete search history.

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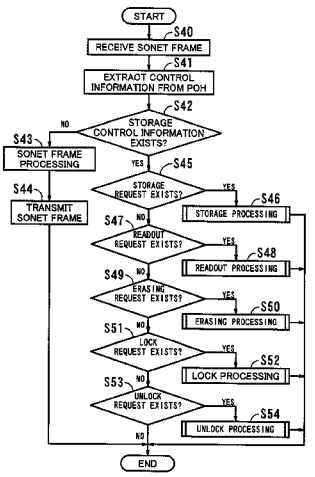
(74) *Attorney, Agent, or Firm*—Katten Muchin Rosenman LLP

(57) **ABSTRACT**

In a method for transmitting data from a first node to a second node through an interlinking network including data transmission equipments: the data is transmitted from the first node to one of the data transmission equipments together with a first request for storage of the data in the one of the data transmission equipments; the data is stored in a storage unit provided in the one of the data transmission equipments in response to the first request; a second request for the data is transmitted from the second node to the one of the data transmission equipments; the data is read out from the storage unit in response to the second request; and the data is transmitted from the one of the data transmission equipments to the second node.

12 Claims, 23 Drawing Sheets



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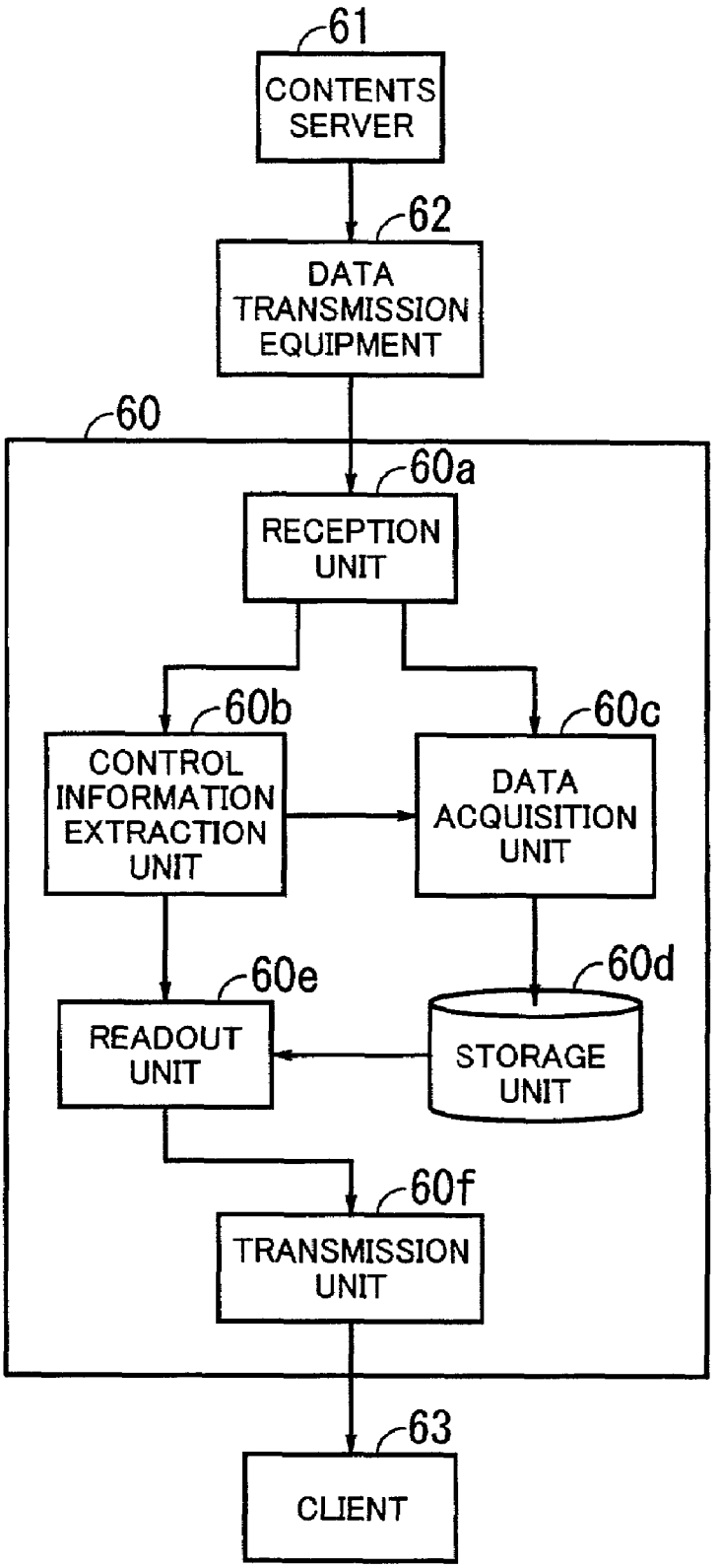
61
CONTENTS SERVER
62
DATA TRANSMISSION EQUIPMENT
60
60a
RECEPTION UNIT
60b
CONTROL INFORMATION EXTRACTION UNIT
60c
DATA ACQUISITION UNIT
60e
READOUT UNIT
60d
STORAGE UNIT
60f
TRANSMISSION UNIT
63
CLIENT

FIG. 1

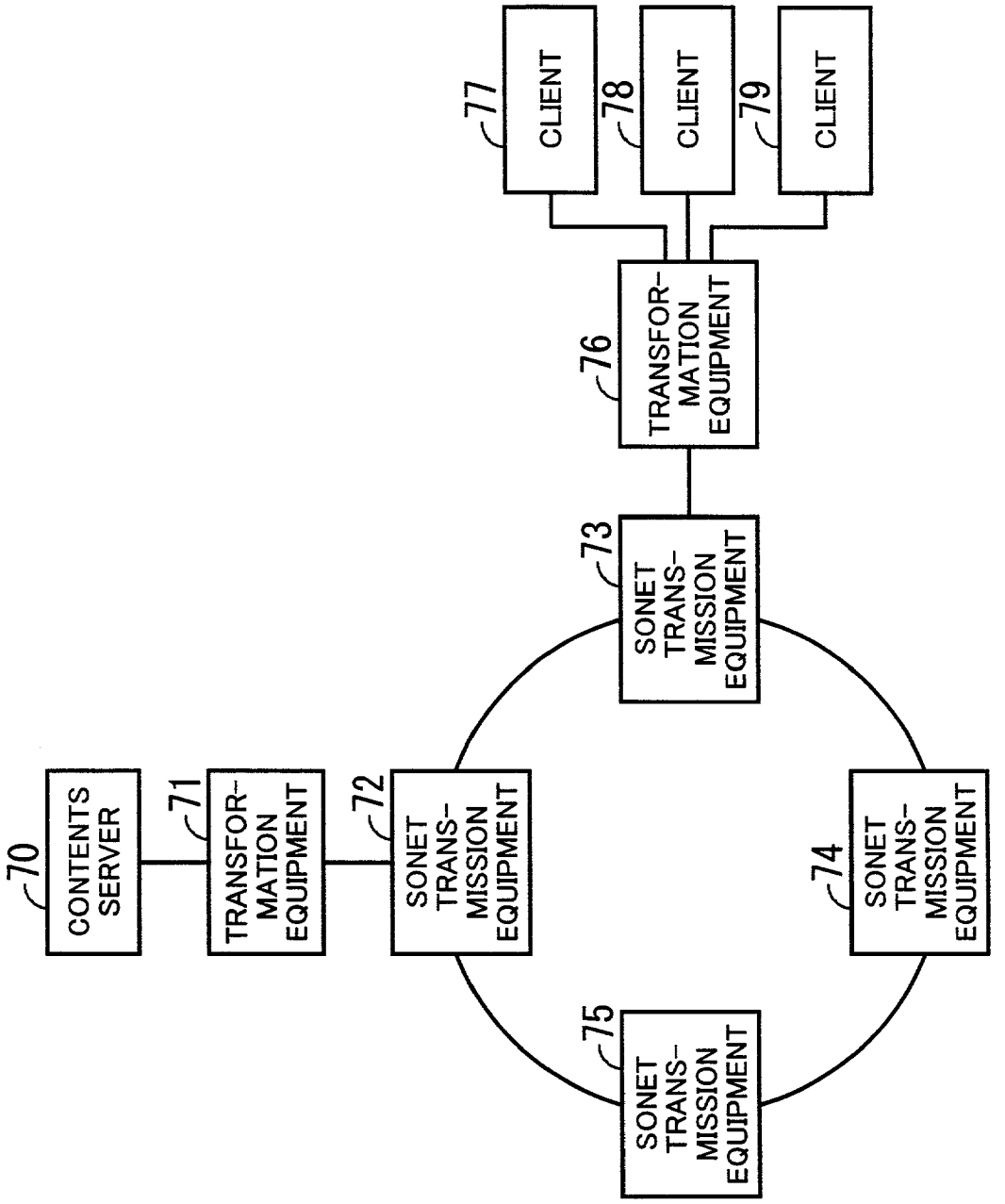
70
CONTENTS SERVER
71
TRANSFOR-MATION EQUIPMENT
72
SONET TRANS-MISSION EQUIPMENT
73
SONET TRANS-MISSION EQUIPMENT
74
SONET TRANS-MISSION EQUIPMENT
75
SONET TRANS-MISSION EQUIPMENT
76
TRANSFOR-MATION EQUIPMENT
77
CLIENT
78
CLIENT
79
CLIENT

FIG. 2

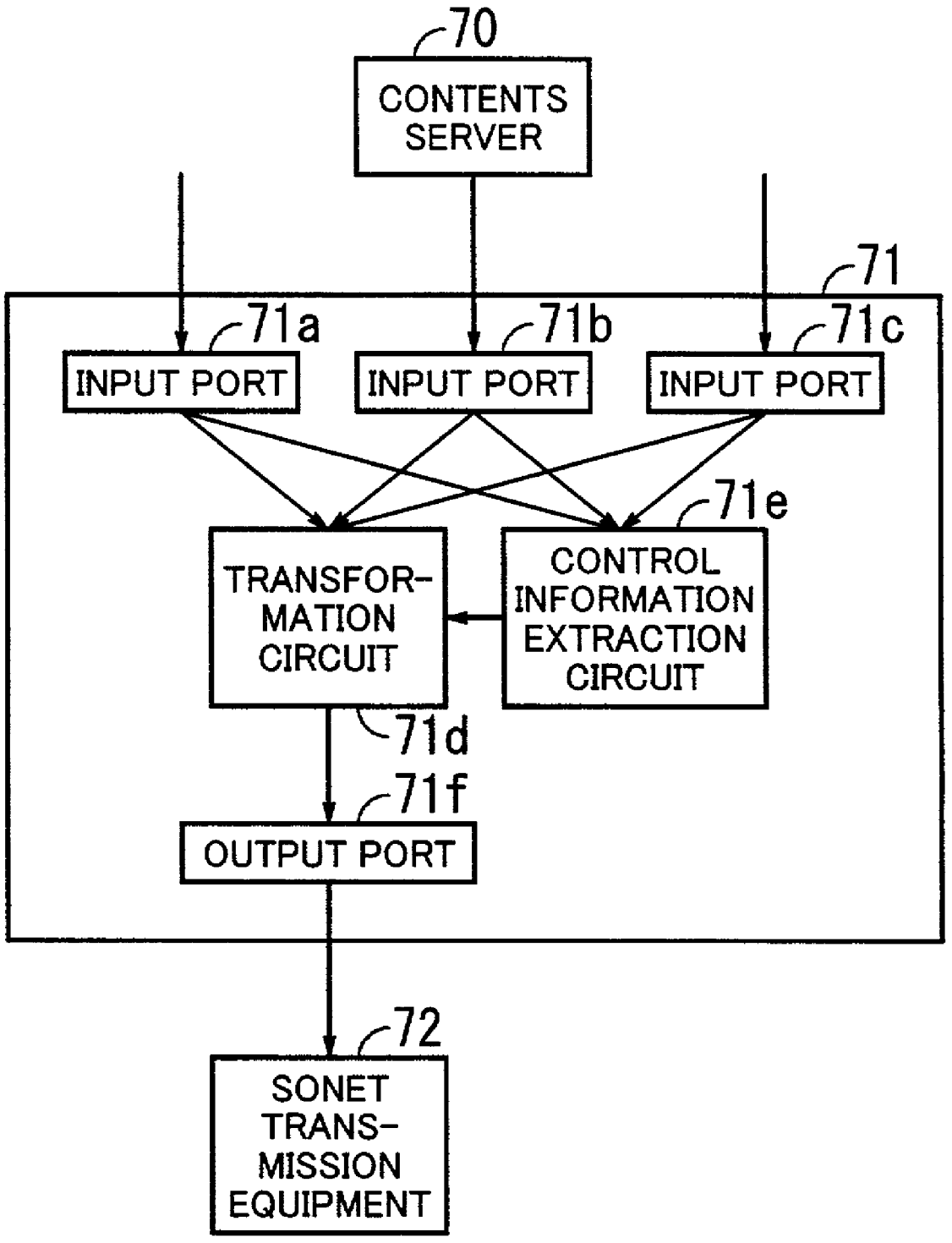
70
CONTENTS SERVER
71
71a
INPUT PORT
71b
INPUT PORT
71c
INPUT PORT
71e
TRANSFOR-MATION CIRCUIT
CONTROL INFORMATION EXTRACTION CIRCUIT
71d
71f
OUTPUT PORT
72
SONET TRANS-MISSION EQUIPMENT

FIG. 3

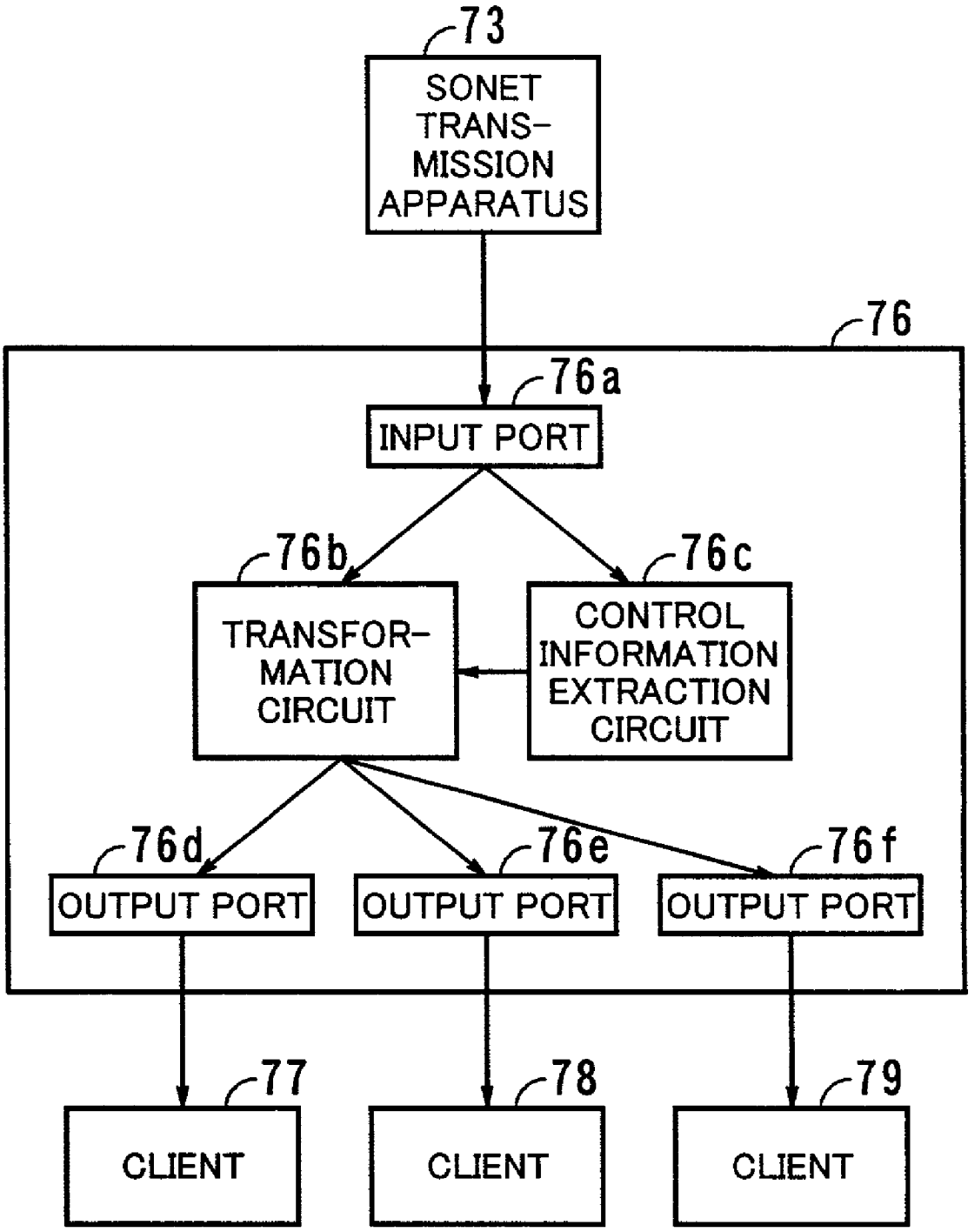
73
SONET TRANS-MISSION APPARATUS
76
76a
INPUT PORT
76b
TRANSFOR-MATION CIRCUIT
76c
CONTROL INFORMATION EXTRACTION CIRCUIT
76d
OUTPUT PORT
76e
OUTPUT PORT
76f
OUTPUT PORT
77
CLIENT
78
CLIENT
79
CLIENT

FIG. 4

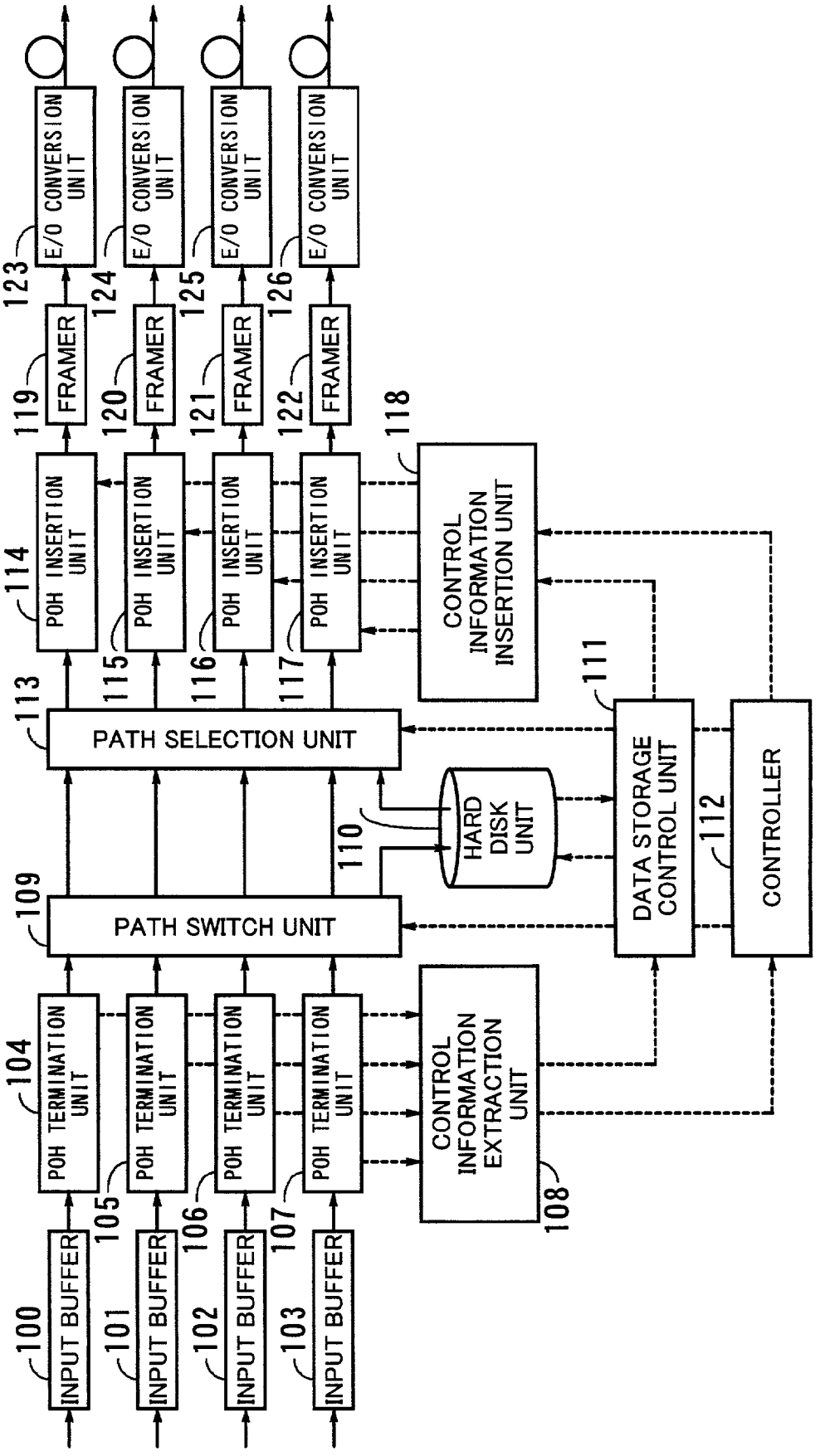
INPUT BUFFER
100
101
102
103
POH TERMINATION UNIT
104
105
106
107
CONTROL INFORMATION EXTRACTION UNIT
108
PATH SWITCH UNIT
109
HARD DISK UNIT
110
DATA STORAGE CONTROL UNIT
111
CONTROLLER
112
PATH SELECTION UNIT
113
POH INSERTION UNIT
114
115
116
117
CONTROL INFORMATION INSERTION UNIT
118
FRAMER
119
120
121
122
E/O CONVERSION UNIT
123
124
125
126

FIG. 5

No.	CONTROL INFORMATION ITEM	FUNCTION
1	DATA STORAGE REQUEST	REQUEST FOR STORAGE OF OBJECT DATA IN STORAGE MEDIUM
2	DATA READOUT REQUEST	REQUEST FOR READOUT OF OBJECT DATA FROM STORAGE MEDIUM
3	DATA ERASING REQUEST	REQUEST FOR ERASING OF OBJECT DATA
4	DATA LOCK REQUEST	REQUEST FOR PROTECTION AGAINST ERASING OF OBJECT DATA
5	DATA UNLOCK REQUEST	REQUEST FOR REMOVAL OF PROTECTION AGAINST ERASING OF OBJECT DATA
6	DATA ID	ID FOR SPECIFYING OBJECT DATA
7	DATA AMOUNT INFORMATION	SIZE OF OBJECT DATA
8	DATA POSITION INFORMATION	POSITION OF OBJECT DATA IN MAIN SIGNAL
9	DESTINATION INFORMATION	DESTINATION OF OBJECT DATA
10	SOURCE INFORMATION	SOURCE OF OBJECT DATA
11	OTHER	FOR FUTURE EXTENSION

FIG. 6

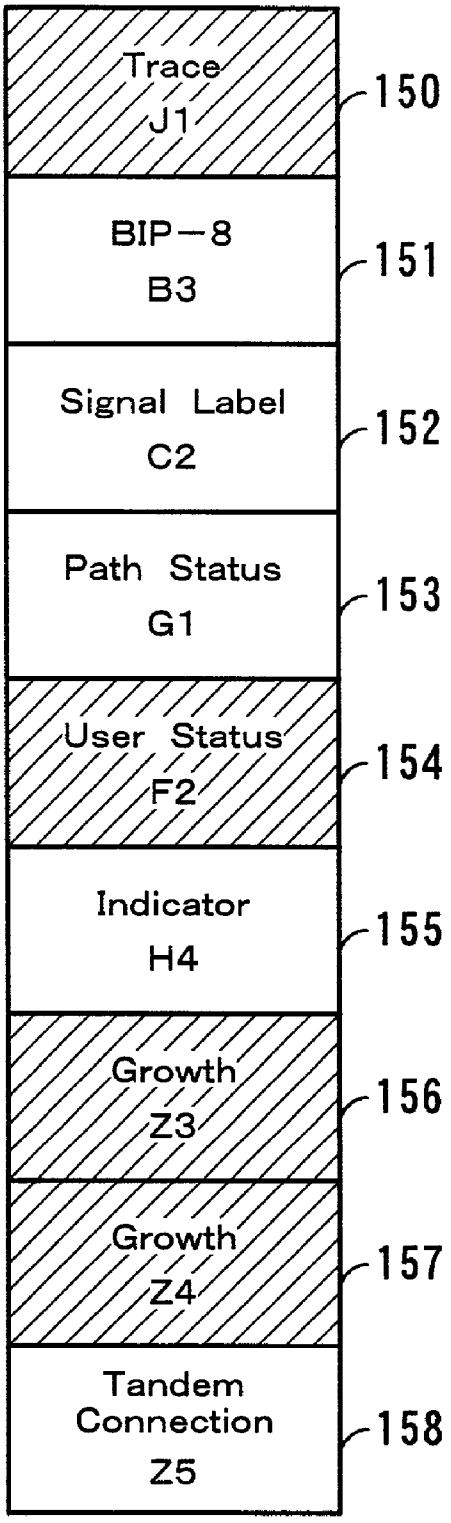
Trace
J1
150
BIP−8
B3
151
Signal Label
C2
152
Path Status
G1
153
User Status
F2
154
Indicator
H4
155
Growth
Z3
156
Growth
Z4
157
Tandem
Connection
Z5
158

FIG. 7

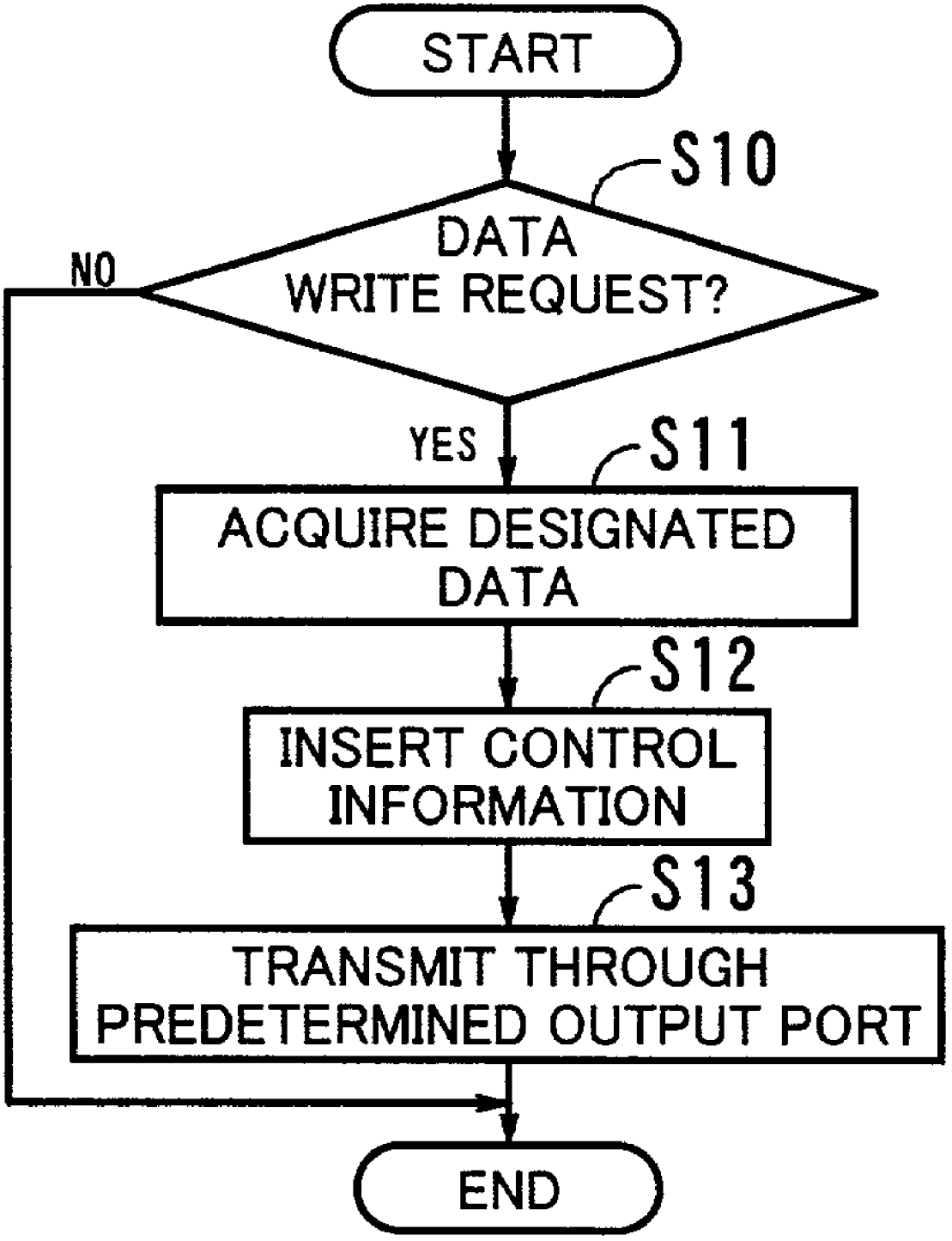
START
S10
DATA WRITE REQUEST?
NO
YES
S11
ACQUIRE DESIGNATED DATA
S12
INSERT CONTROL INFORMATION
S13
TRANSMIT THROUGH PREDETERMINED OUTPUT PORT
END

FIG. 8

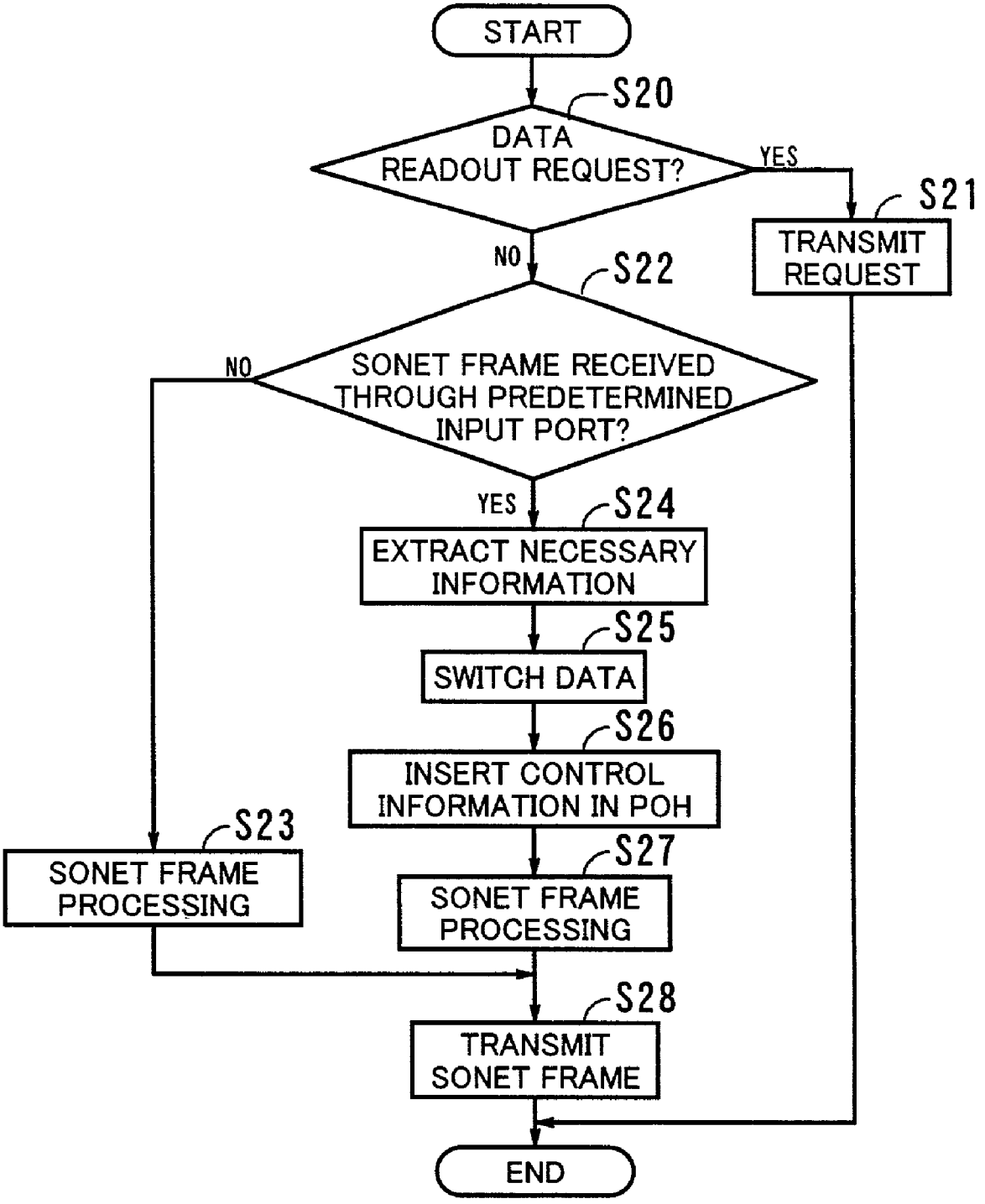
START
S20
DATA READOUT REQUEST?
YES
S21
TRANSMIT REQUEST
NO
S22
SONET FRAME RECEIVED THROUGH PREDETERMINED INPUT PORT?
NO
YES
S24
EXTRACT NECESSARY INFORMATION
S25
SWITCH DATA
S26
INSERT CONTROL INFORMATION IN POH
S23
SONET FRAME PROCESSING
S27
SONET FRAME PROCESSING
S28
TRANSMIT SONET FRAME
END

FIG. 9

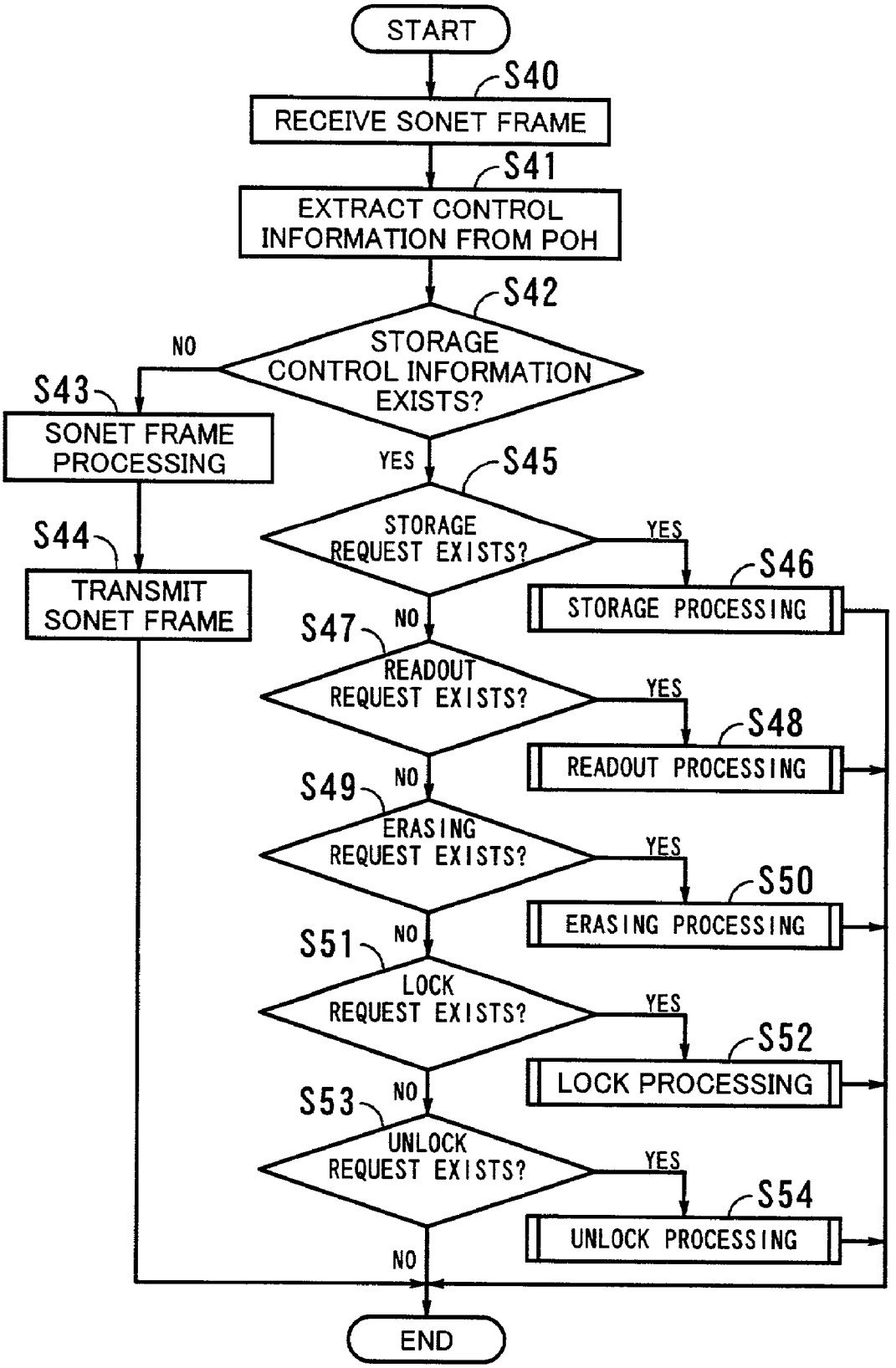
START
S40
RECEIVE SONET FRAME
S41
EXTRACT CONTROL INFORMATION FROM POH
S42
STORAGE CONTROL INFORMATION EXISTS?
NO
S43
SONET FRAME PROCESSING
S44
TRANSMIT SONET FRAME
YES
S45
STORAGE REQUEST EXISTS?
YES
S46
STORAGE PROCESSING
NO
S47
READOUT REQUEST EXISTS?
YES
S48
READOUT PROCESSING
NO
S49
ERASING REQUEST EXISTS?
YES
S50
ERASING PROCESSING
NO
S51
LOCK REQUEST EXISTS?
YES
S52
LOCK PROCESSING
NO
S53
UNLOCK REQUEST EXISTS?
YES
S54
UNLOCK PROCESSING
NO
END

FIG. 10

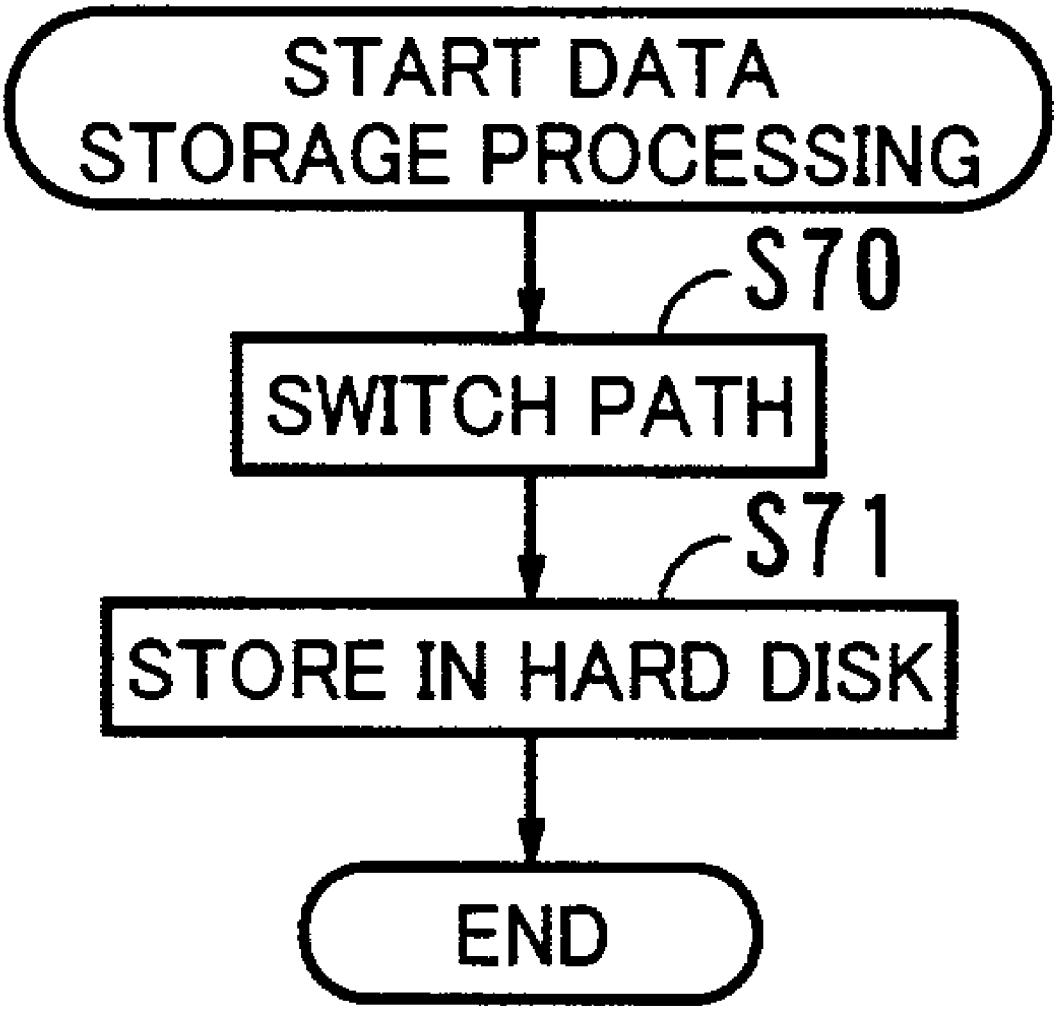
START DATA STORAGE PROCESSING
S70
SWITCH PATH
S71
STORE IN HARD DISK
END

FIG. 11

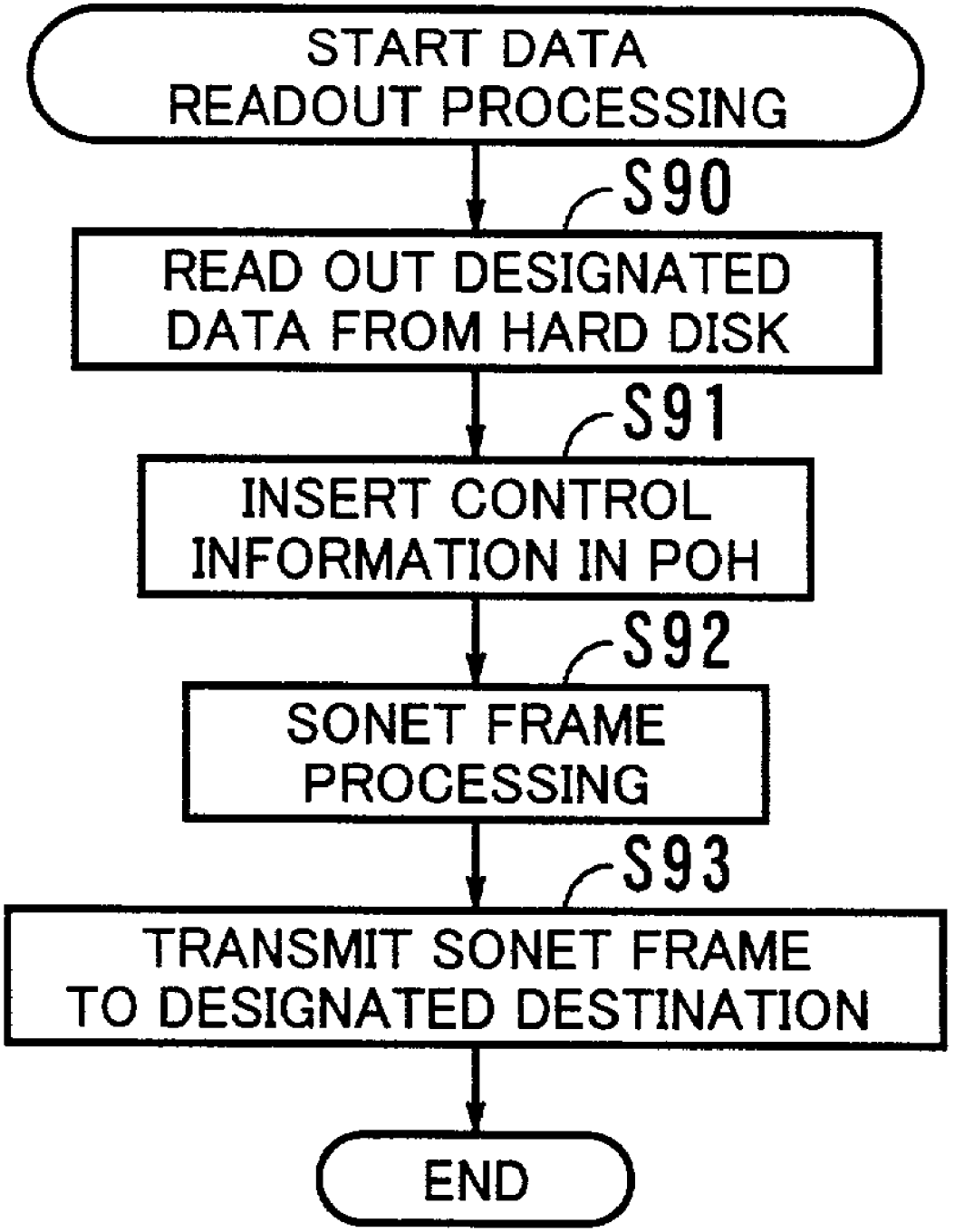
START DATA READOUT PROCESSING
S90
READ OUT DESIGNATED DATA FROM HARD DISK
S91
INSERT CONTROL INFORMATION IN POH
S92
SONET FRAME PROCESSING
S93
TRANSMIT SONET FRAME TO DESIGNATED DESTINATION
END

FIG. 12

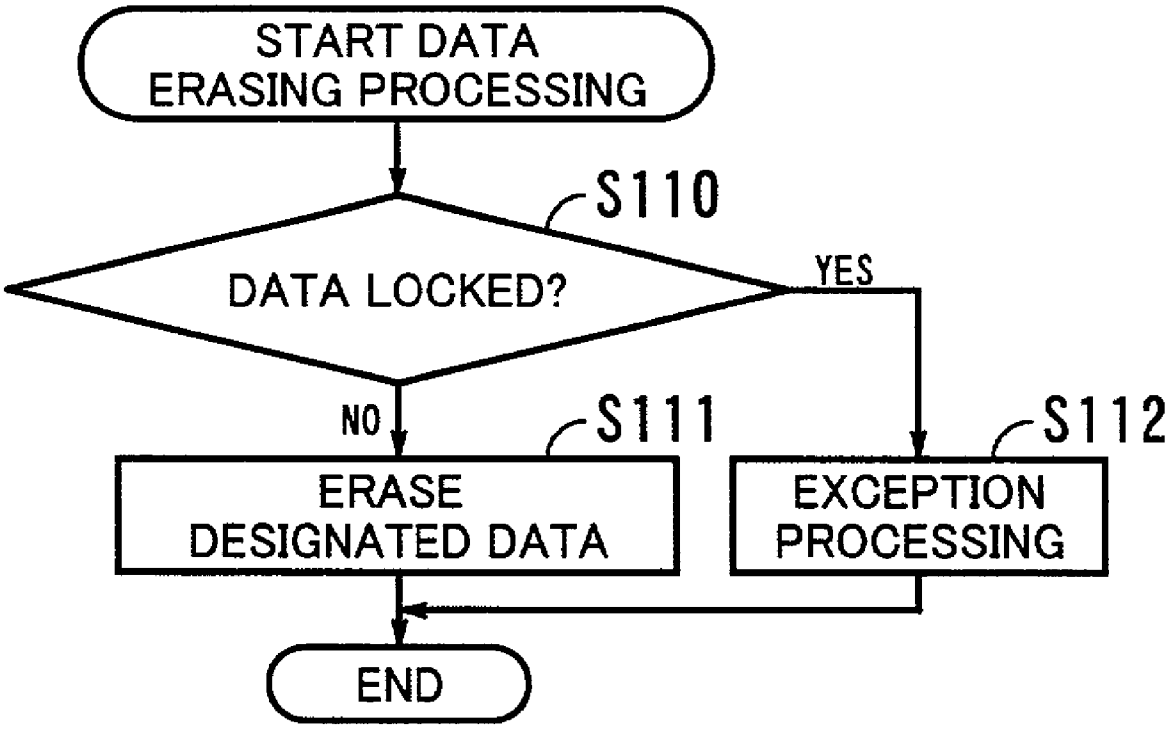
START DATA ERASING PROCESSING
S110
DATA LOCKED?
YES
NO
S111
ERASE DESIGNATED DATA
S112
EXCEPTION PROCESSING
END

FIG. 13

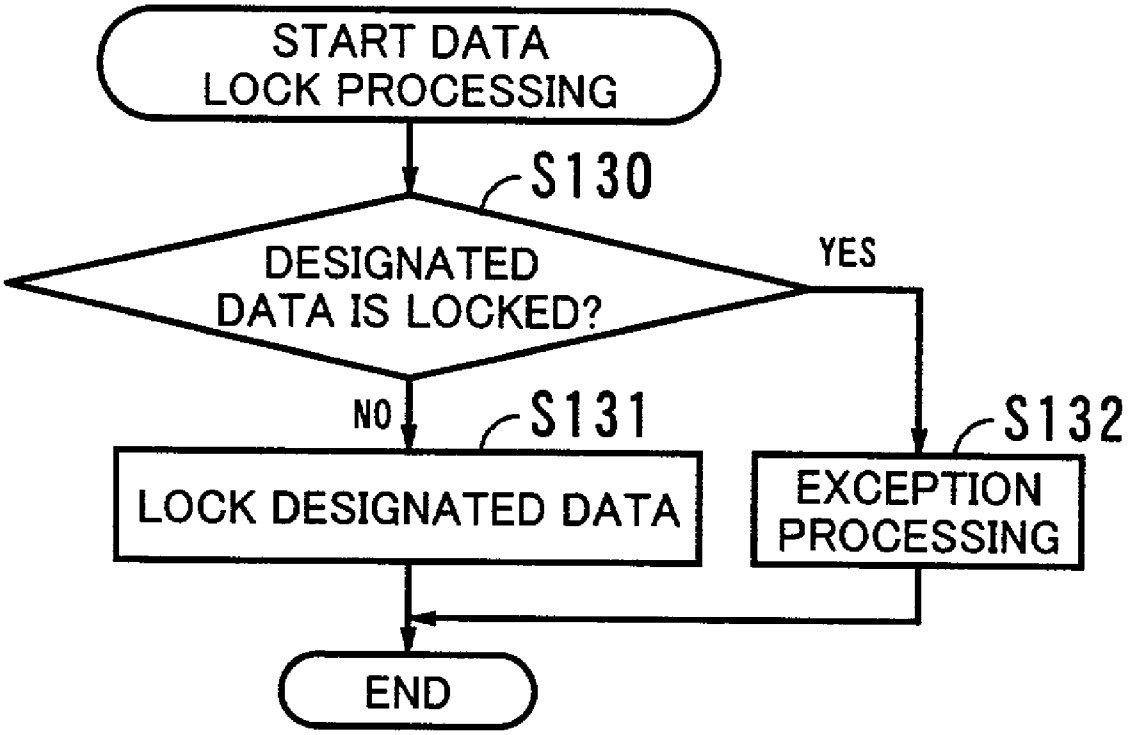
START DATA LOCK PROCESSING
S130
DESIGNATED DATA IS LOCKED?
YES
NO
S131
LOCK DESIGNATED DATA
S132
EXCEPTION PROCESSING
END

FIG. 14

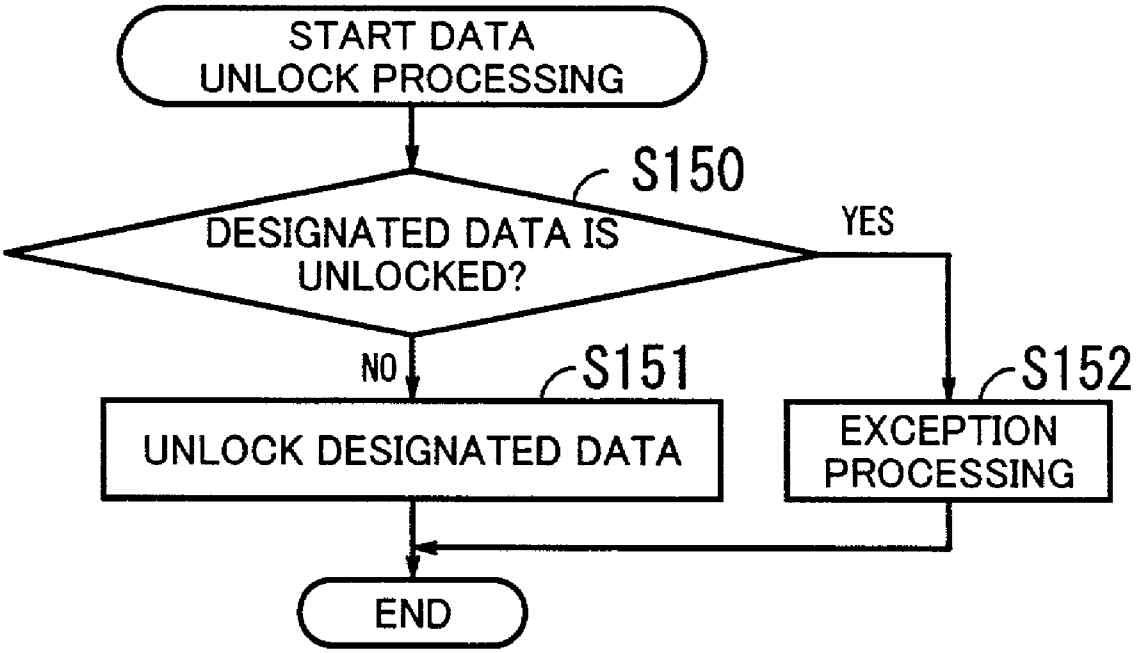
START DATA UNLOCK PROCESSING
S150
DESIGNATED DATA IS UNLOCKED?
YES
NO
S151
UNLOCK DESIGNATED DATA
S152
EXCEPTION PROCESSING
END

FIG. 15

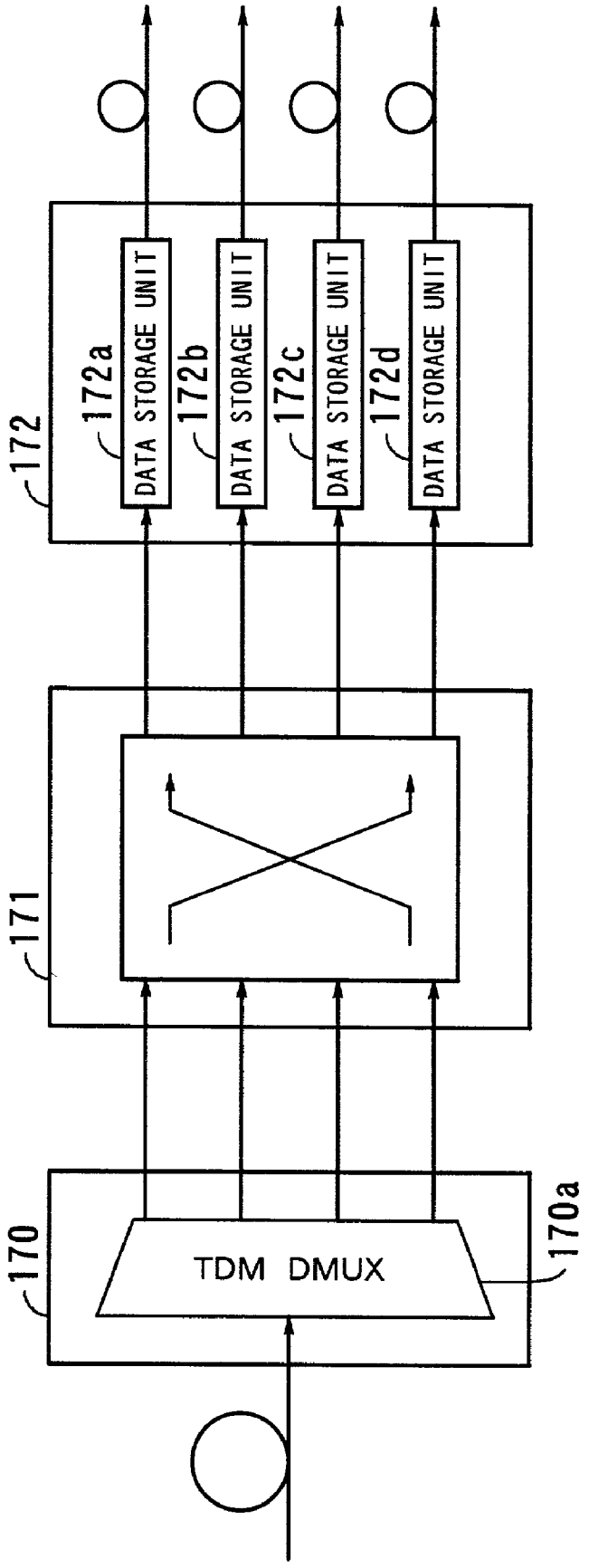
172
172a
DATA STORAGE UNIT
172b
DATA STORAGE UNIT
172c
DATA STORAGE UNIT
172d
DATA STORAGE UNIT
171
170
TDM DMUX
170a

FIG. 16

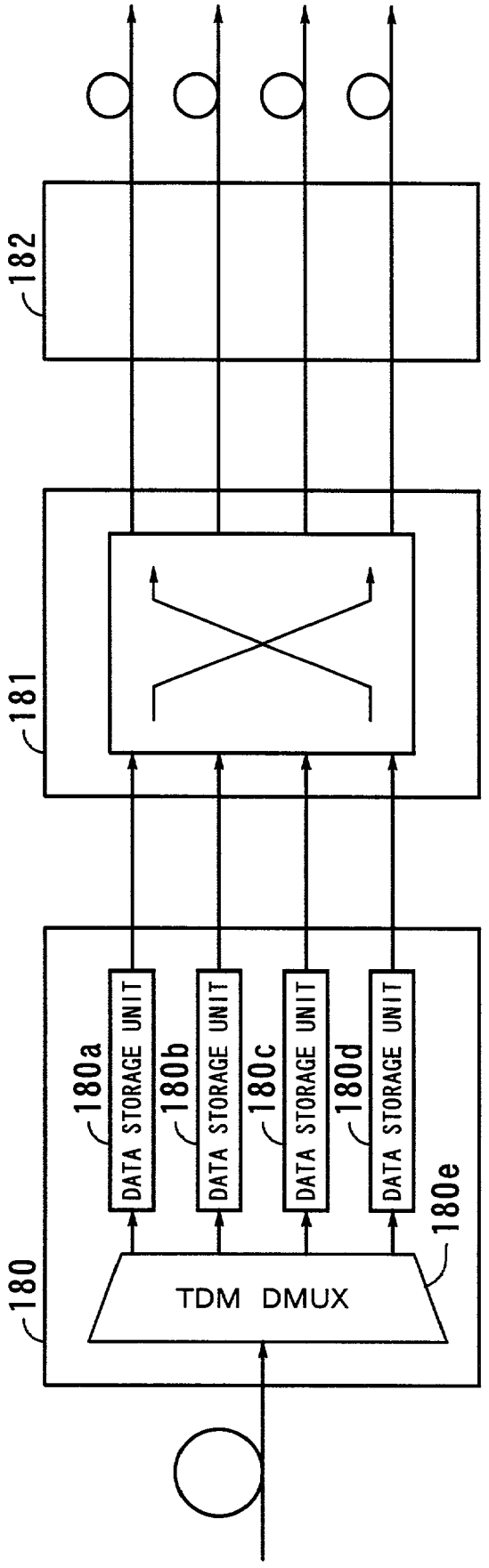
182
181
180
180a
180b
180c
180d
180e
DATA STORAGE UNIT
DATA STORAGE UNIT
DATA STORAGE UNIT
DATA STORAGE UNIT
TDM DMUX

FIG. 17

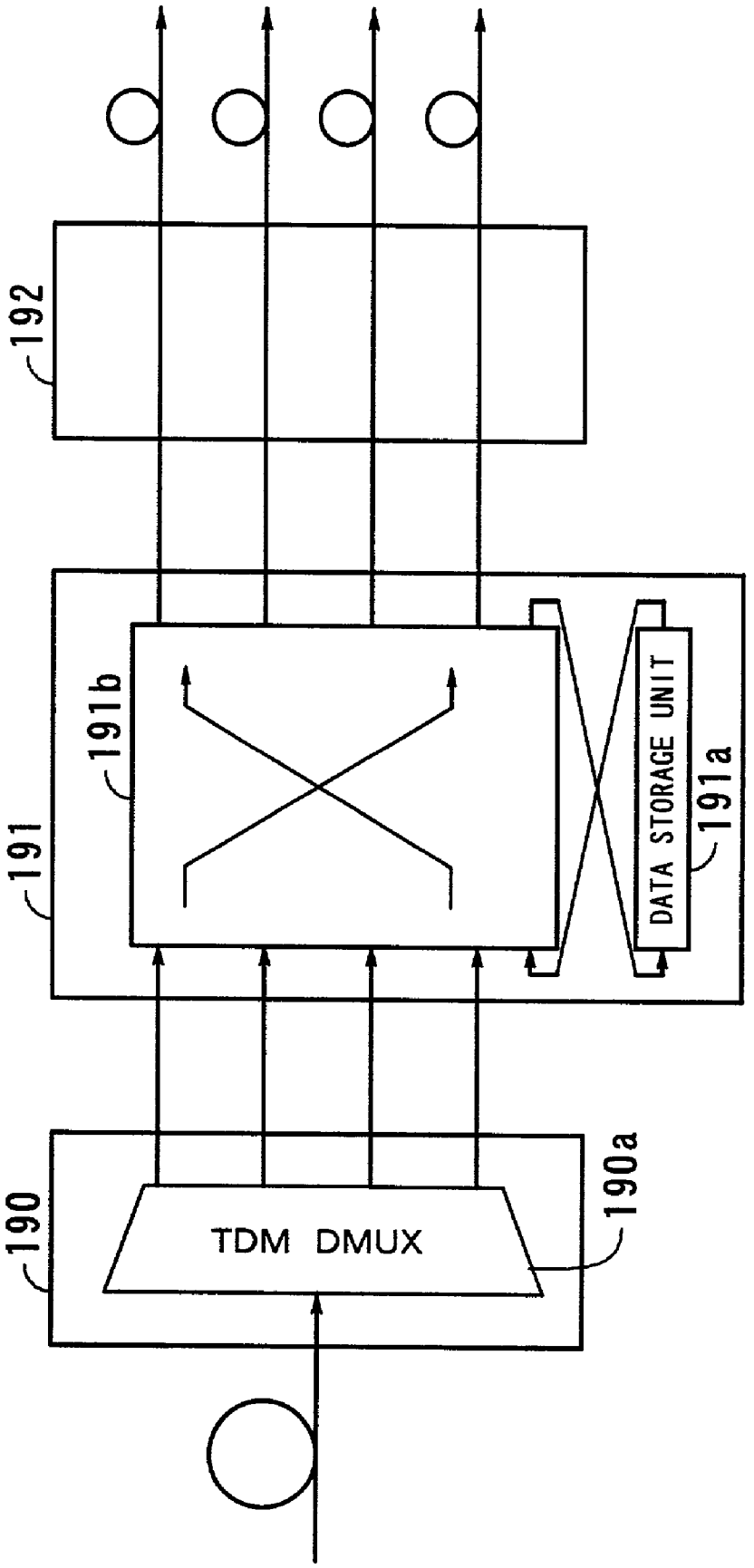

FIG. 18

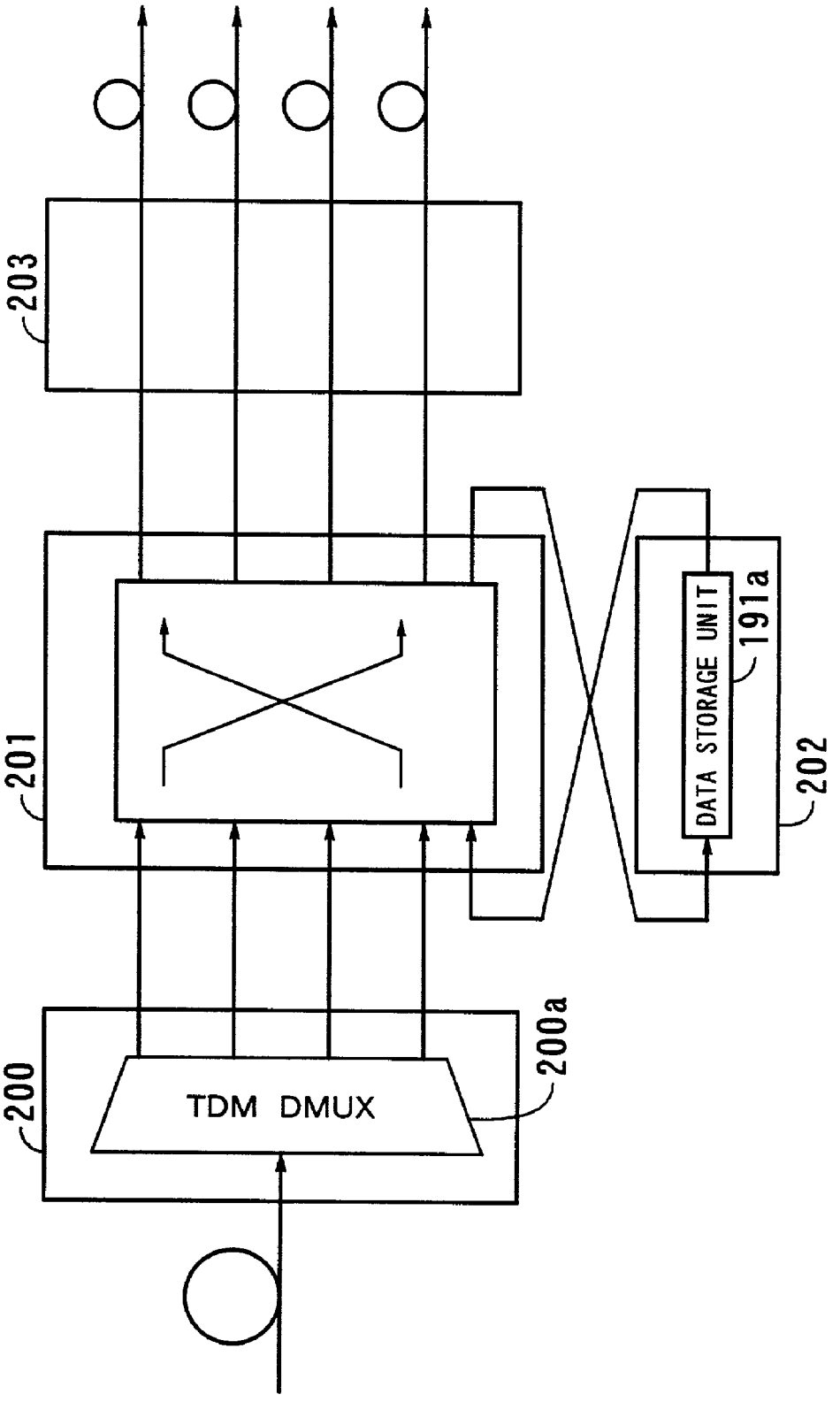

FIG. 19

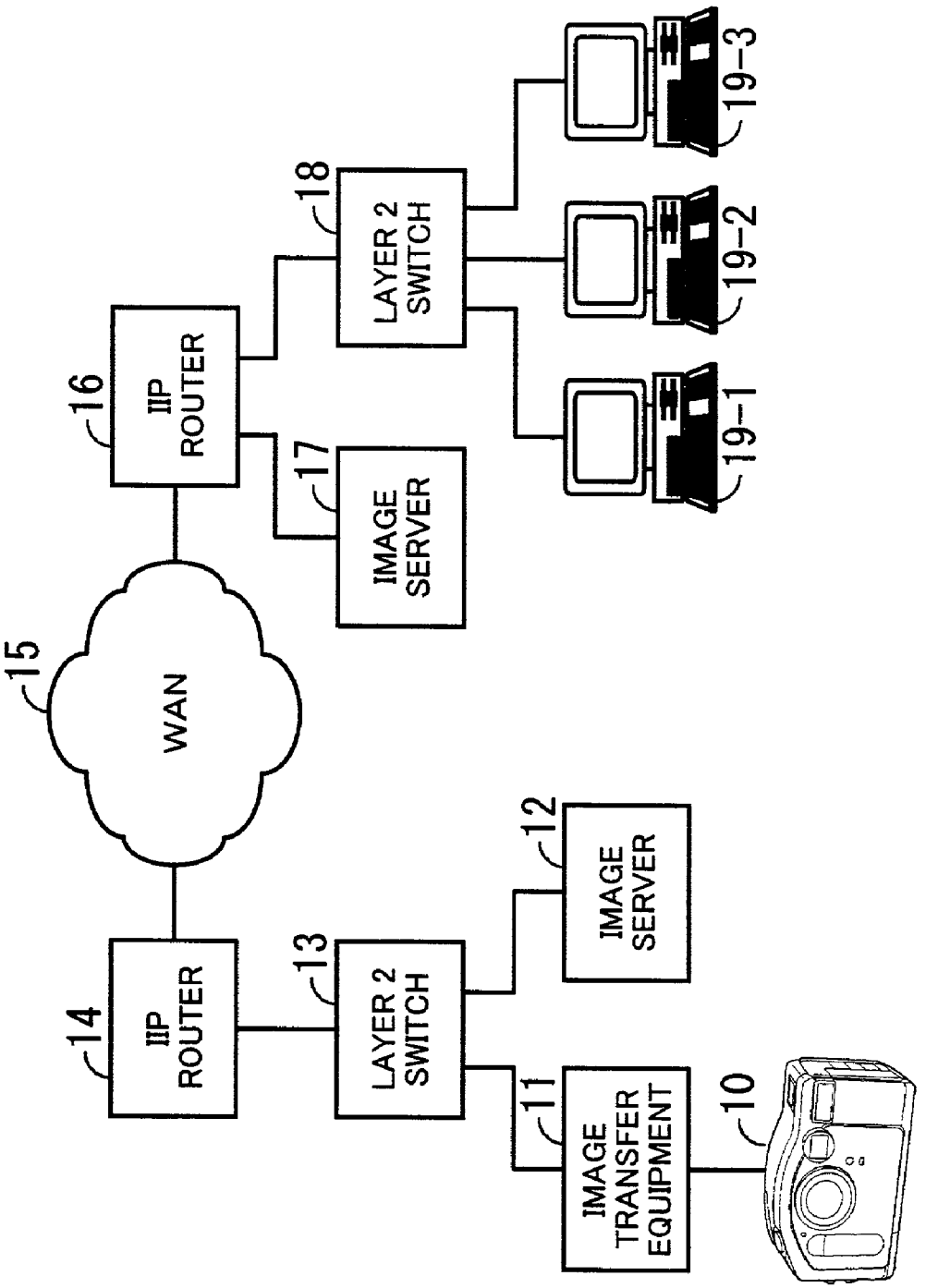

FIG. 20
PRIOR ART

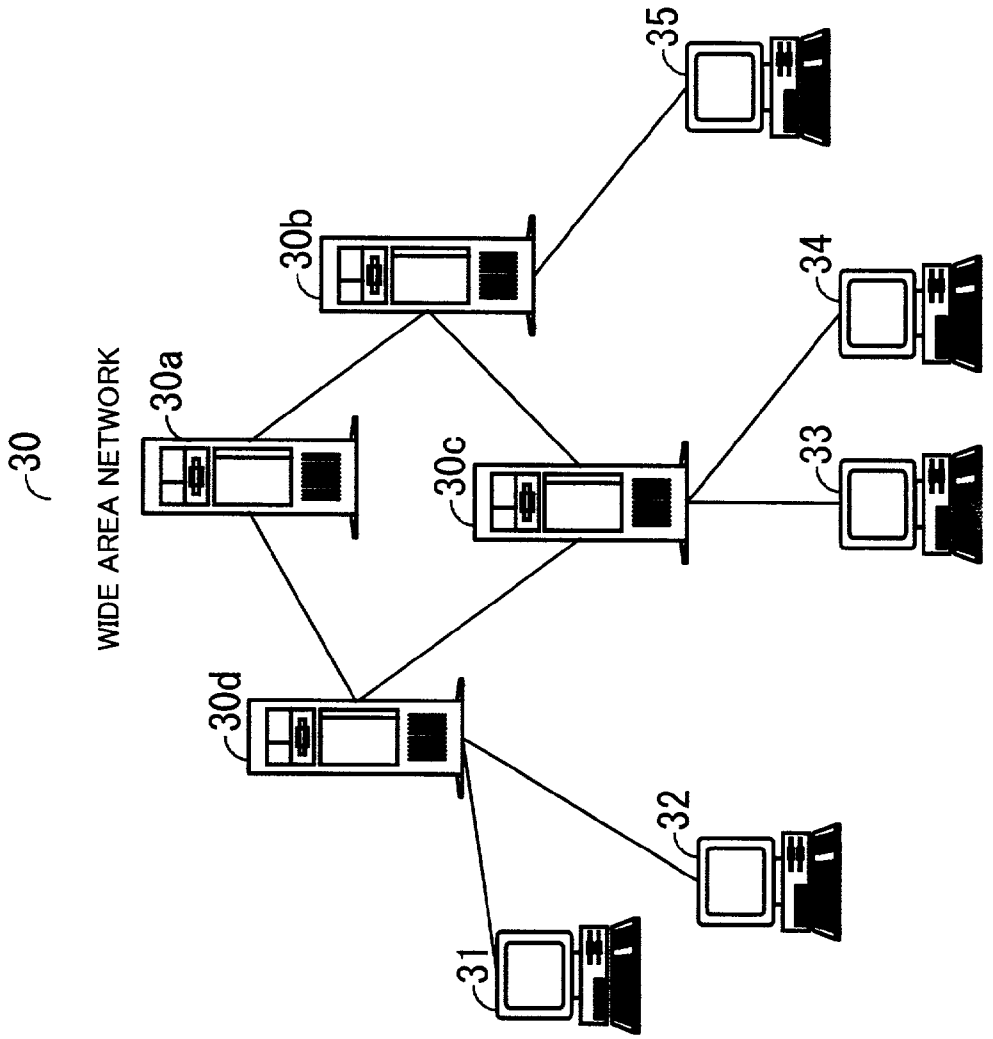

FIG. 21
PRIOR ART

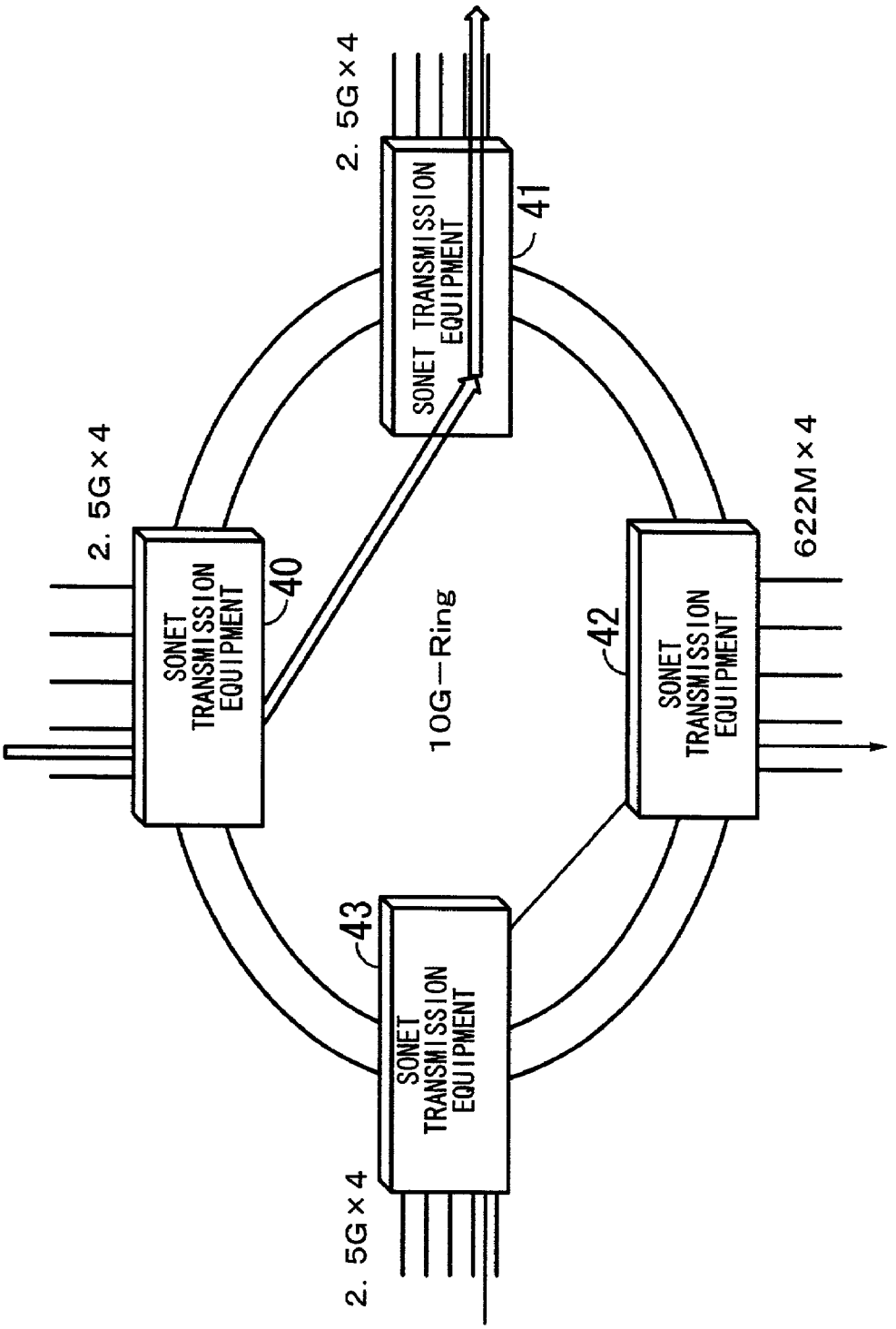

FIG. 22
PRIOR ART

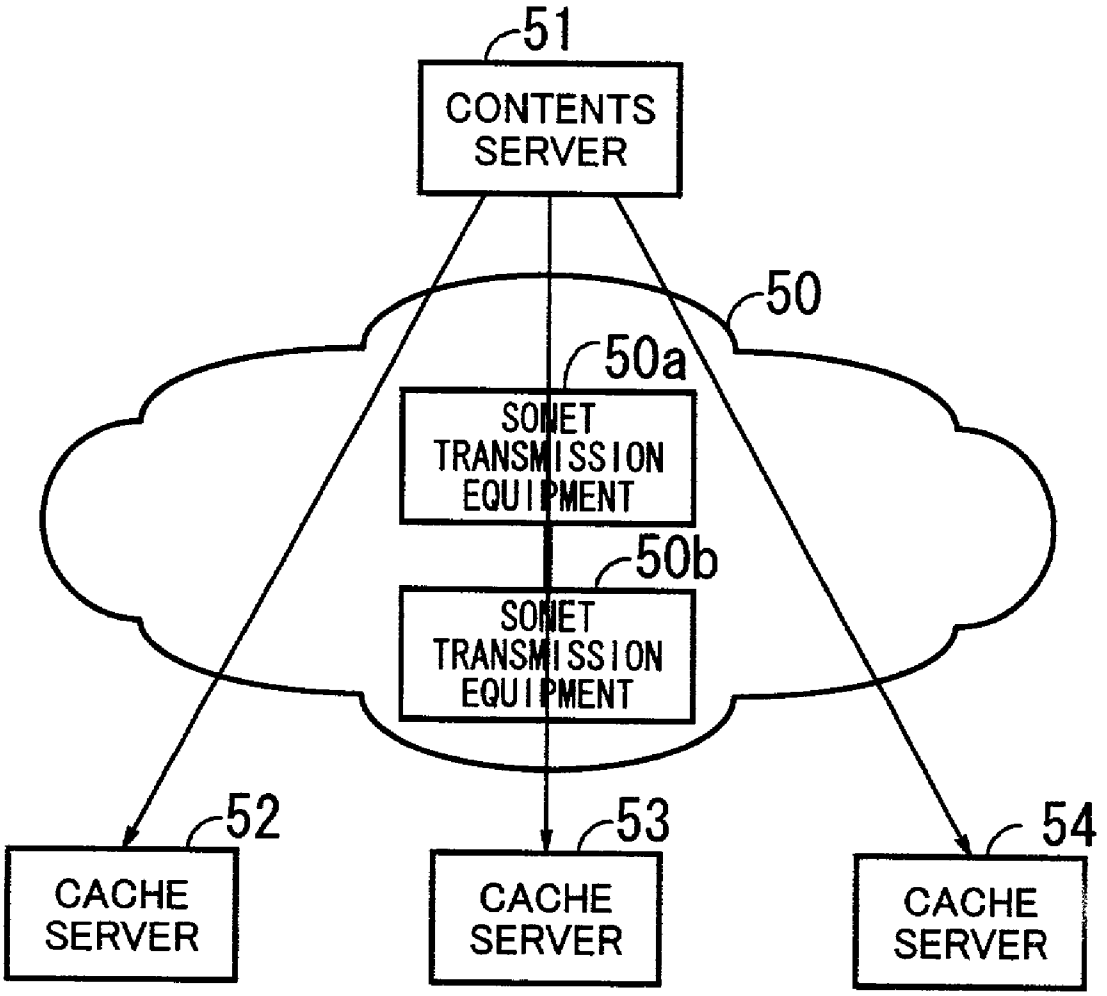

FIG. 23
PRIOR ART

METHOD AND SYSTEM FOR TRANSMITTING DATA IN TWO STEPS BY USING DATA STORAGE PROVIDED IN DATA TRANSMISSION EQUIPMENT IN NETWORK

BACKGROUND OF THE INVENTION

1) Field of the Invention

The present invention relates to a method for transmitting data from a first network node (e.g., an information server) to a second network node (e.g., a client) through an interlinking network which includes a plurality of transmission equipments. The present invention also relates to a data transmission system including a plurality of transmission equipments and transmitting data from a first network node to a second network node. The present invention further relates to a transmission equipment used in a data transmission system interconnecting first and second network nodes.

2) Description of the Related Art

Recently, the bandwidths of local networks have been increased, and the bandwidths of the access networks have also been increased by the development of the technologies of XDSL (X Digital Subscriber Line), FTTH (Fiber To The Home), and the like. With the increase in the bandwidths of the local and access networks, business opportunities are increasing, and various services are becoming available. In such a situation, increase in the bandwidths of backbone or interlinking networks (e.g., use of broadband networks) is also required.

In particular, attempts are currently made to transmit data requiring wide bandwidth (e.g., sound data or image data) by using the IP (Internet Protocol) platform. For example, in some applications such as delivery of radio programs or music, the attempted data transmission has become commercially practical. In addition, low-quality image delivery services have already become commercially practical.

Currently, in order to realize the above data transmission using the IP platform, many distributed systems have been constructed by arranging a number of cache servers in the Internet. In such distributed systems, data are delivered by network elements using the IP multicast technique.

In addition, in order to increase the overall throughput of the data transmission system and realize music or images delivery services to a wide area, attempts have been made to directly connect a LAN (Local Area Network) to a broadband, backbone or interlinking network such as a SONET (or SDH) network or a WDM (Wavelength Division Multiplex) network. It is considered that the direct connection of a LAN to a SONET (or SDH) network or a WDM network will be widely used in the future.

Next, the data transmission using the IP platform and the transmission through the SONET (or SDH) network are explained below.

(i) Data Transmission Using IP Platform

FIG. **20** is a diagram illustrating an example of a conventional image delivery or cable television system which uses the Internet. The example of FIG. **20** has a typical LAN-WAN (Wide Area Network)-LAN configuration.

In FIG. **20**, reference numeral **10** denotes a camera, **11** denotes an image transfer equipment, **12** denotes an image server, **13** denotes an L**2** (Layer **2**) switch, **14** denotes an IIP (Internet Imaging Protocol) router, **15** denotes a WAN, **16** denotes an IIP router, **17** denotes an image server, **18** denotes an L**2** switch, and **19-1** to **19-3** each denote a client.

The camera **10** captures an image of an object and sound, converts the image and sound into digital data, and outputs the digital data. The image transfer equipment **11** generates an IP packet containing the digital data output from the camera **10**, and transmits the IP packet through the L**2** switch **13**. Each of the image servers **12** and **17** temporarily stores image data, and transmits the image data in response to a request from the clients **19-1** to **19-3**. Each of the L**2** switches **13** and **18** performs packet switching in the data link layer. Each of the IIP routers **14** and **16** transfers image data in accordance with a protocol for exchanging image data and related information.

For example, the WAN **15** is realized by an ATM (Asynchronous Transfer Mode) network, a SONET (or SDH) network, an ISDN network, or the like, and uses the MPLS (Multiprotocol Label Switching) technique.

Each of the clients **19-1** to **19-3** receives image data and displays an image.

The image data and the sound data output from the camera **10** are delivered to the clients **19-1** to **19-3** in different manners according to the services requested by the clients **19-1** to **19-3**.

In a first type of service, the image data and the sound data output from the camera **10** are temporarily stored in the image server **17**. Thereafter, when one of the clients **19-1** to **19-3** makes a request for the image data and the sound data, the image data and the sound data are transmitted to the one of the clients **19-1** to **19-3** through the L**2** switch **18**.

In a second type of service (real-time delivery service), the image data and the sound data output from the camera **10** are first contained in an IP packet by the image transfer equipment **11**, and then multicast delivered to the clients **19-1** to **19-3** by using the IP multicast technique.

However, the volume of image data transmitted in the conventional image delivery or cable television system is basically great. In particular, television broadcasting constantly requires for each channel a bandwidth of 3 to 10 Mbit/s in the case of standard definition television data and 20 Mbit/s in the case of high definition television data. In the case of sound data, a bandwidth of 80 to 130 Kbit/s is required.

Therefore, the conventional system is sufficient to deliver the sound data. However, in order to deliver the image data, it is necessary to control the bandwidth and increase the transmission rate in the entire system including the LANs and WANs. For example, in the case where 10 channels of high definition television data are delivered, a bandwidth of 200 Mbps (=20 Mbps×10 ch) is constantly required.

Nevertheless, the constant flow of the above traffic impedes transmission of other information, and is not economical.

It is well known that bottlenecks in networks are typically caused by differences in the interface speed between LANs and WANs. For example, many WANs have ISDN (64/1,544 Kbps DS1), ATM (155 Mbps), or XDSL interfaces for connection to users. In addition, in an increasing number of cases of transmission, data transmitted from the users through the ISDN, ATM, or XDSL interfaces are multiplexed by using the SONET or SDH technology and transmitted through transmission lines of OC-3 (155 Mbps), OC-12 (622 Mbps), OC-48 (2.5 Gbps), OC-192 (10 Gbps), or the like. In order to realize the above operation, for example, a POS (Packet Over Sonet) unit is installed in IP routers. On the other hand, recently, many LANs uses the Ethernet having a transmission rate of 100 Mbps or 1 Gbps. That is, the bandwidths of the interfaces between the WANs and the LANs are much smaller than those of the LANs and WANs, and the transmission is delayed by the small bandwidths of the interfaces between the WANs and the LANs.

Further, in transmission of a great amount of images and sound data, images and sound received by clients (users' PCs) may be interrupted when packets are delayed, discarded, or

disordered by the influence of the reduction of the bandwidth in the WAN and the best effort transmission of IP packets.

In order to solve the above problem, conventionally, cache servers are distributed in the Internet so that information is stored by the cache servers, and the delay, discard, and disorder of the packets are absorbed.

FIG. **21** is a diagram illustrating an example of a configuration of cache servers in the Internet. In FIG. **21**, the other network elements such as IP routers and hubs are not shown.

As illustrated in FIG. **21**, the cache servers **30***a* to **30***d* are distributed in the WAN **30**, the clients **31** and **32** are connected to the cache server **30***d*, the clients **33** and **34** are connected to the cache server **30***c*, and the client **35** is connected to the cache server **30***b*.

Since the cache servers **30***a* to **30***d* are arranged near the corresponding clients **31** to **35**, it is possible to avoid inefficient access to original contents in response to each connection request, improve response, and reduce traffic.

(ii) Conventional SONET or SDH System

The SONET transmission equipments are high-speed transmission equipments mainly used in backbone networks of network providers, and various data such as data of telephones, leased lines, and IP packets, for which the network providers provide service, are transmitted through the SONET transmission equipments. The SONET transmission equipments multiplex such data into a high-speed transmission signal having a transmission rate of 2.5 Gbps, 10 Gbps, 40 Gbps, or the like, and transmit the high-speed transmission signal through a single optical fiber, by using the SONET or SDH technology. In SONET or SDH networks, each path has uniform traffic, and synchronism is maintained.

FIG. **22** is a diagram for explaining the bandwidths of incoming lines and corresponding outgoing lines. In the path indicated by the double lines with arrows the example of FIG. **22**, the transmission line incoming into the SONET transmission equipment **40** and the transmission line outgoing from the SONET transmission equipment **41** have an identical transmission rate 2.5 Gbps. On the other hand, in the path indicated by the single lines with arrows, the transmission line incoming into the SONET transmission equipment **43** has an transmission rate 2.5 Gbps, and the transmission line outgoing from the SONET transmission equipment **42** has an transmission rate 622 Mbps. This is impractical.

In the packet transmission of data, basically, more than one network terminal shares a transmission line (i.e., a bandwidth of a transmission line), and the synchronism is not secured. On the other hand, in the SONET networks, bandwidth allocation to each transmission line is predetermined, and the synchronism is maintained.

However, conventionally, in order to provide a broadband service in a wide area, cache servers and other network elements are required to be distributed over the wide area under various conditions. Therefore, sufficient bandwidths are not necessarily secured between a data source server and the cache servers. In this case, the amount of data output from the data source server is limited. Thus, even when the bandwidth is great in only a portion (e.g., in an interlinking network such as a SONET or SDH network) of a transmission path between the data source server and each cache server, the great bandwidth of the portion cannot be efficiently used.

Further, in a broadband service such as an image or sound delivery service, data sent to the respective cache servers are often identical. However, conventionally, the data source server is required to send the identical data to each cache server separately. FIG. **23** is a diagram illustrating an example of a configuration for transmitting data from a data source server to a plurality of cache servers in a conventional data delivery service system. In the example of FIG. **23**, the contents server (data source server) **51** is required to send identical data to each of the cache servers **52** to **54**, i.e., the contents server **51** is required to transmit the identical data three times. Therefore, utilization efficiency of the bandwidth of the WAN **50** is low.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method for efficiently transmitting a great volume of data such as image data or sound data from a first network node to a second network node through an interlinking network.

Another object of the present invention is to provide a data transmission system which can efficiently transmit a great volume of data such as image data or sound data from a first network node to a second network node through an interlinking network.

A further object of the present invention is to provide a data transmission equipment which can be used in a data transmission system, and realize efficient transmission of a great volume of data such as image data or sound data in the data transmission system.

(I) According to the first aspect of the present invention, there is provided a method for transmitting data from a first network node to a second network node through an interlinking network including a plurality of data transmission equipments. The method comprises the steps of: (a) transmitting the data together with a first request for storage of the data in one of the plurality of data transmission equipments, from the first network node to the one of the plurality of data transmission equipments; (b) receiving the data and the first request by the one of the plurality of data transmission equipments; (c) storing the data in a storage unit provided in the one of the plurality of data transmission equipments, based on the first request; (d) transmitting a second request for the data, from the second network node to the one of the plurality of data transmission equipments; (e) receiving the second request by the one of the plurality of data transmission equipments; (f) reading out the data from the storage unit based on the second request; and (g) transmitting the data from the one of the plurality of data transmission equipments to the second network node.

According to the first aspect of the present invention, data transmitted from the first network node is temporarily stored in the storage unit in the one of the plurality of data transmission equipments in accordance with the first request, and is thereafter transmitted to the second network node in response to a second request from the second network node. Therefore, the transmission of data from the first network node to the one of the plurality of data transmission equipments can be performed independently of the transmission rate between the one of the plurality of data transmission equipments and the second network node, and can be therefore performed at high speed. In addition, the data can be transmitted from the one of the plurality of data transmission equipments to the second network node at a transmission rate which is optimum for the second network node.

Further, the operations for readout and transmission of the data to the second network node do not affect traffic between the first network node and the one of the plurality of data transmission equipments.

In the method according to the first aspect of the present invention, the step (d) may comprise the substeps of: (d1) transmitting the second request from the second network node to the first network node; and (d2) transferring the

second request from the first network node to the one of the plurality of data transmission equipments.

In addition, in the step (a), the data and the first request may be multiplexed.

(II) According to the second aspect of the present invention, there is provided a data transmission system comprising: a plurality of network nodes; and an interlinking network which includes a plurality of data transmission equipments, interlinks the plurality of network nodes, and transmits data between the plurality of network nodes in a multiplexed form. In the data transmission system, one of the plurality of data transmission equipments includes: a reception unit which receives first data; a control information extraction unit which extracts control information from the first data received by the reception unit; a data acquisition unit which determines whether or not the control information includes a request for storage of the first data, and acquires the first data when the control information includes the request for storage of the first data; and a data storage unit which stores the first data acquired by the data acquisition unit.

In the data transmission system according to the second aspect of the present invention, the one of the plurality of data transmission equipments may further include: a data readout unit which determines whether or not the control information includes a request for readout of second data stored in the data storage unit, and reads out the second data from the data storage unit when the control information includes the request for readout of the second data; and a transmission unit which transmits the second data to a destination.

(III) According to the third aspect of the present invention, there is provided a data transmission equipment for use as a constituent of a multiplex transmission network. The data transmission equipment comprises: a reception unit which receives first data; a control information extraction unit which extracts control information from the first data received by the reception unit; a data acquisition unit which determines whether or not the control information includes a request for storage of the first data, and acquires the first data when the control information includes the request for storage of the first data; and a data storage unit which stores the first data acquired by the data acquisition unit.

The data transmission equipment according to the third aspect of the present invention may also have one or any possible combination of the following additional features (i) to (x). p (i) The data transmission equipment according to the third aspect of the present invention may further comprise: a data readout unit which determines whether or not the control information includes a request for readout of second data stored in the data storage unit, and reads out the second data from the data storage unit when the control information includes the request for readout of the second data; and a transmission unit which transmits the second data to a destination. p (ii) The reception unit receives the first data at a first transmission rate, the transmission unit transmits the second data at a second transmission rate, and the first and second transmission rates can be determined independently of each other. p (iii) The transmission unit transmits the second data to a plurality of destinations. p (iv) The data transmission equipment according to the third aspect of the present invention may further comprise a control information insertion unit which inserts control information in the second data transmitted by the transmission unit. p (v) The data transmission equipment according to the third aspect of the present invention may further comprise a data erasing unit which determines whether or not the control information includes a request for erasing of third data stored in the data storage unit, and erases the third data from the data storage unit when the control information includes the request for erasing of the third data p (vi) The data storage unit is arranged in the reception unit. p (vii) The data storage unit is arranged in the transmission unit. p (viii) The data transmission equipment according to the third aspect of the present invention may further comprise a switch unit which cross-connects transmission lines, and the data storage unit is arranged in the switch unit. p (ix) The reception unit receives the first data in accordance with one of SONET and SDH technologies. p (x) The transmission unit transmits the second data in accordance with one of SONET and SDH technologies. p (IV) The above and other objects, features and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings which illustrate preferred embodiment of the present invention by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a diagram illustrating a basic construction of the data transmission system according to the present invention;

FIG. **2** is a diagram illustrating an example of a data transmission system as a first embodiment of the present invention;

FIG. **3** is a diagram illustrating an example of a construction of the transformation equipment **71**;

FIG. **4** is a diagram illustrating an example of a construction of the transformation equipment **76**;

FIG. **5** is a diagram illustrating an example of a construction of the SONET transmission equipment **73**;

FIG. **6** shows examples of information items which can be included in control information;

FIG. **7** shows the fields (bytes) in a POH in a virtual tributary;

FIG. **8** is a flow diagram indicating an example of a sequence of operations performed by the transformation equipment **71**;

FIG. **9** is a flow diagram indicating an example of a sequence of operations performed by the SONET transmission equipment **72**;

FIG. **10** is a flow diagram indicating an example of a sequence of operations performed by the SONET transmission equipment **73**;

FIG. **11** is a flow diagram indicating details of the data storage processing in step S**46** in FIG. **10**;

FIG. **12** is a flow diagram indicating details of the data readout processing in step S**48** in FIG. **10**;

FIG. **13** is a flow diagram indicating details of the data erasing processing in step S**50** in FIG. **10**;

FIG. **14** is a flow diagram indicating details of the data lock processing in step S**52** in FIG. **10**;

FIG. **15** is a flow diagram indicating details of the data unlock processing in step S**54** in FIG. **10**;

FIG. **16** is a diagram illustrating an outline of a construction of a SONET transmission equipment used in a second embodiment of the present invention;

FIG. **17** is a diagram illustrating an outline of a construction of a SONET transmission equipment used in a third embodiment of the present invention;

FIG. **18** is a diagram illustrating an outline of a construction of a SONET transmission equipment used in a fourth embodiment of the present invention;

FIG. **19** is a diagram illustrating an outline of a construction of a SONET transmission equipment used in a fifth embodiment of the present invention;

FIG. **20** is a diagram illustrating an example of a conventional image delivery or cable television system which uses the Internet;

FIG. **21** is a diagram illustrating an example of a configuration of cache servers in the Internet;

FIG. **22** is a diagram for explaining the bandwidths of incoming lines and corresponding outgoing lines; and

FIG. **23** is a diagram illustrating an example of a configuration for transmitting data from a data source server to a plurality of cache servers in a conventional data delivery service system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention are explained in detail below with reference to drawings.

(1) Basic Construction

FIG. **1** is a diagram illustrating a basic construction of the data transmission system according to the present invention. In FIG. **1**, reference numeral **61** denotes a contents server, **60** and **62** each denote a data transmission equipment, and **63** denotes a client. As illustrated in FIG. **1**, the data transmission equipments **62** and **60** are connected between the contents server **61** and the client **63**, and constitute a WAN. The contents server **61** transmits data (e.g., image data) to be supplied to the client **63**. For example, the client **63** is a terminal of a user, and realized by a personal computer. The WAN may include other data transmission equipments, and the data transmission system of FIG. **1** may include other client.

The data transmission equipment **60** comprises a reception unit **60***a*, a control information extraction unit **60***b*, a data acquisition unit **60***c*, a storage unit **60***d*, a readout unit **60***e*, and a transmission unit **60***f*.

The reception unit **60***a* in the data transmission equipment **60** receives data transmitted from the data transmission equipment **62**. The control information extraction unit **60***b* extracts control information from the data received by the reception unit **60***a*. When the control information extracted by the control information extraction unit **60***b* includes a request for storage of data, the data acquisition unit **60***c* acquires the data from the data received by the reception unit **60***a*. The storage unit **60***d* stores the data acquired by the data acquisition unit **60***c*. When the control information extracted by the control information extraction unit **60***b* includes a request for readout of the data stored in the storage unit **60***d*, the readout unit **60***e* reads out the data from the storage unit **60***d*. The transmission unit **60***f* transmits to the client **63** the data read out by the readout unit **60***e*.

(2) Operation of Basic Construction

First, the contents server **61** supplies to the data transmission equipment **62** data (for example, image data) and a request for storage of the image data in the storage unit **60***d* in the data transmission equipment **60**. When the data transmission equipment **62** receives the image data and the request for storage, the data transmission equipment **62** generates first control information which indicates the requests for storage of the image data in the storage unit **60***d* in the data transmission equipment **60**, based on the image data, and transmits the image data and the first control information to the data transmission equipment **60**. The reception unit **60***a* in the data transmission equipment **60** receives the image data and the first control information transmitted from the data transmission equipment **62**. The first control information extraction unit **60***b* in the data transmission equipment **60** extracts the first control information, recognizes that the first control information includes a request for storage, and supplies the first control information to the data acquisition unit **60***c*. The data acquisition unit **60***c* acquires a portion or all of the image data associated with the first control information, and stores the portion or all of the image data in an area of the storage unit **60***d*.

In the above operations, the transmission of data from the contents server **61** to the data transmission equipment **60** can be performed independently of the transmission rate between the data transmission equipment **60** and the client **63**, and can be therefore performed at high speed.

Next, when the client **63** sends to the contents server **61** a request for readout of the image data from the storage unit **60***d* in the data transmission equipment **60** in the situation in which the image data is stored in the storage unit **60***d* in the data transmission equipment **60**, the contents server **61** sends to the data transmission equipment **60** through the data transmission equipment **62** second control information which indicates the request for readout of the image data from the storage unit **60***d* in the data transmission equipment **60**. The control information extraction unit **60***b* in the data transmission equipment **60** extracts the second control information, recognizes that the second control information includes a request for readout, and supplies the second control information to the readout unit **60***e*. The readout unit **60***e* reads out from the storage unit **60***d* a portion or all of the image data stored in the storage unit **60***d* and designated by the second control information, and supplies to the transmission unit **60***f* the portion or all of the image data read out from the storage unit **60***d*. The transmission unit **60***f* transmits to the client **63** the portion or all of the image data read out from the storage unit **60***d*.

During the above operations for readout and transmission to the client **63**, only the second control information is transmitted between the contents server **61** and the data transmission equipment **60**. Therefore, the operations for readout and transmission to the client **63** do not affect data transmission for the other users.

In addition, the transmission rate between the transmission unit **60***f* in the data transmission equipment **60** and the client **63** can be determined independently of the transmission rate between data transmission equipment **62** and the data transmission equipment **60**. Therefore, the data can be transmitted from the data transmission equipment **60** to the client **63** at an optimum transmission rate for the client **63**.

When a plurality of clients are connected to the transmission unit **60***f*, the transmission unit **60***f* can concurrently transmit identical data to the plurality of clients.

As explained above, in the data transmission system according to the present invention, the storage unit **60***d* is provided in the data transmission equipment **60** for storing data supplied by the contents server **61**, and thereafter, the data is read out and transmitted to the client **63** in response to a request from the client **63**. Therefore, the transmission of data from the contents server **61** to the data transmission equipment **60** is not affected by the transmission rate between the data transmission equipment **60** and the client **63** and can be performed at high speed. In addition, the transmission of data from the data transmission equipment **60** to the client **63** can be performed at an optimum transmission rate for the client **63**.

(3) Construction of First Embodiment

FIG. **2** is a diagram illustrating an example of a data transmission system as the first embodiment of the present invention. In FIG. **2**, reference numeral **70** denotes a contents

server, **71** and **76** each denote a transformation equipment, **72** to **75** each denote a SONET transmission equipment, and **77** to **79** each denote a client.

The contents server **70** stores image data and sound data, and transmits a portion of the image data and sound data in response to a request from the clients **77** to **79** or an information provider, which provides information delivery services and is not shown in FIG. **2**.

Hereinafter, for simplicity of explanation, it is assumed that the data transmitted in the data transmission system according to the present invention are image data. However, any data which do not require real-time transmission can be transmitted in the data transmission system according to the present invention.

The transformation equipment **71** receives IP packets being transmitted from the contents server **70** and containing image data and control information, transforms the IP packets into SONET frames, and transmits the SONET frames to the SONET transmission equipment **72**. In the SONET frames, the image data and the control information are associated with each other.

FIG. **3** is a diagram illustrating an example of a construction of the transformation equipment **71**. The transformation equipment **71** of FIG. **3** comprises input ports **71***a* to **71***c*, a transformation circuit **71***d*, a control information extraction circuit **71***e*, and an output port **71***f*. The input ports **71***a* to **71***c* are connected to the contents server **70** and other nodes (not shown), and the transformation equipment **71** receives IP packets through the input ports **71***a* to **71***c*.

The control information extraction circuit **71***e* extracts control information from the IP packets received through the input ports **71***a* to **71***c*, and supplies the extracted control information to the transformation circuit **71***d*. The transformation circuit **71***d* transforms the IP packets into SONET frames, and supplies the SONET frames to the output port **71***f*. The control information extracted by the control information extraction circuit **71***e* is inserted in the SONET frames as a portion of overhead information. The output port **71***f* transmits the SONET frames to the SONET transmission equipment **72**.

Referring back to FIG. **2**, the transformation equipment **76** receives SONET frames from the SONET transmission equipment **73**, transforms the received SONET frames into IP packets, and transmits the IP packets to the clients **77** to **79** according to control information contained in the received SONET frames.

FIG. **4** is a diagram illustrating an example of a construction of the transformation equipment **76**. The transformation equipment **76** of FIG. **4** comprises an input port **76***a*, a transformation circuit **76***b*, a control information extraction circuit **76***c*, and output ports **76***d* to **76***f*. The transformation equipment **76** receives SONET frames from the SONET transmission equipment **73** through the input port **76***a*. The control information extraction circuit **76***c* extracts control information from the SONET frames received through the input port **76***a*, and supplies the extracted control information to the transformation circuit **76***b*. The transformation circuit **76***b* transforms the received SONET frames into IP packets, and transmits the IP packets to the output ports **76***d* to **76***f*. The control information extracted by the control information extraction circuit **76***c* is inserted in the headers of the IP packets. The IP packets are transmitted to the clients **77** to **79** through the output ports **76***d* to **76***f*. Alternatively, the output ports **76***d* to **76***f* in the transformation equipment **76** may be replaced with a single output port. In this case, the IP packets output from the single output port can be transferred to the clients **77** to **79** by using a router or the like.

Referring back to FIG. **2**, the SONET transmission equipments **72** to **75** each have a function of a SONET ADM (add-drop multiplexer), and realize high-speed data transmission by multiplexing and demultiplexing received data. In the example of FIG. **2**, the SONET transmission equipments **72** to **75** constitute a RING network which transmits, for example, OC-768 signals having a transmission rate of 40 Gbps.

FIG. **5** is a diagram illustrating an example of a construction of the SONET transmission equipment **73**. The SONET transmission equipment **73** of FIG. **5** comprises input buffers **100** to **103**, POH termination units **104** to **107**, a control information extraction unit **108**, a path switch unit **109**, a hard disk unit **110**, a data storage control unit **111**, a controller **112**, a path selection unit **113**, POH insertion units **114** to **117**, a control information insertion unit **118**, framers **119** to **122**, and E/O conversion units **123** to **126**. Although not shown in FIG. **5**, the SONET transmission equipment **73** further comprises a TDM (Time Division Multiplex) demultiplexing unit which receives SONET frames, and demultiplexes the SONET frames into virtual tributaries and other overhead information.

The input buffers **100** to **103** temporarily store the virtual tributaries of the received SONET frames, and respectively supply the temporarily stored virtual tributaries to the POH termination units **104** to **107**. The POH termination units **104** to **107** extracts POHs (path overheads) each including control information from the virtual tributaries supplied from the input buffers **100** to **103**, under control of the control information extraction unit **108**, and supply the extracted POHs to the control information extraction unit **108** and data portions of the SONET frames to the path switch unit **109**. The control information extraction unit **108** receives the POHs extracted by the POH termination units **104** to **107**, extracts the control information from the POHs, and supplies the control information and the other portions of the POHs to the data storage control unit **111** and the controller **112**.

The path switch unit **109** switches the data portions of the SONET frames under control of the data storage control unit **111** or the controller **112**. The hard disk unit **110** stores data supplied from the path switch unit **109**, and supplies data stored in the hard disk unit **110** to the path selection unit **113**, under control of the data storage control unit **111** or the controller **112**. The data storage control unit **111** controls the operations of storing data in the hard disk unit **110** and reading data from the hard disk unit **110**. The controller **112** monitors and controls the entire SONET transmission equipment and flows of data in the SONET transmission equipment. The path selection unit **113** selects paths of data under control of the data storage control unit **111** or the controller **112**.

The POH insertion units **114** to **117** insert POHs in virtual tributaries containing the data portions output from the path selection unit **113**, respectively, under control of the control information insertion unit **118**. The control information insertion unit **118** controls the POH insertion units **114** to **117** so that control information is included in the POHs inserted in the virtual tributaries. The framers **119** to **122** produce SONET frames containing the virtual tributaries output from the POH insertion units **114** to **117**, respectively. The E/O conversion units **123** to **126** generate optical signals conveying the SONET frames produced by the framers **119** to **122**, by electrical-to-optical conversion.

Referring back to FIG. **2**, each of the clients **77** to **79** sends to the contents server **70** a request for transmission of image data (or sound data), receives the image data (or sound data),

and displays an image represented by the received image data on a display device (not shown) or outputs sound data by a speaker (not shown).

(4) Operations of First Embodiment

The operations of the first embodiment are explained below.

First, the operations of the data transmission system of FIG. **2** in response to a request for storage are explained below.

When the aforementioned information provider sends to the contents server **70** a request for transmission of data (e.g., image data) to the SONET transmission equipment **73** and storage of the data in the SONET transmission equipment **73**, the contents server **70** supplies the data which is designated to be stored, to the transformation equipment **71** through an input port which is predetermined to be used when data designated to be stored is input into the transformation equipment **71**. In the example of FIG. **3**, the data supplied from the contents server **70** is input into the transformation equipment **71** through the input port **71***b*. In addition, the contents server **70** supplies control information to the transformation equipment **71**. At this time, the control information includes information items Nos. **1**, **6**, **7**, **8**, **9**, and **10** illustrated in FIG. **6**.

FIG. **6** shows examples of information items which can be included in control information. The information item No. **1** is a data storage request, which is a request for storage of object data in a storage medium, the information item No. **6** is a data ID, which designates the object data, the information item No. **7** is data amount information, which indicates the size of the object data, the information item No. **8** is data position information, which indicates the position of the object data in a main signal, the information item No. **9** is destination information, which indicates a destination of the object data, and the information item No. **10** is source information, which indicates a source of the object data.

In addition, the information item No. **2** is a data readout request, which is a request for readout of object data from a storage medium, the information item No. **3** is a data erasing request, which is a request for erasing of object data in a storage medium, the information item No. **4** is a data lock request, which is a request for locking (i.e., protection against erasing) of the object data stored in a storage medium, and the information item No. **5** is a data unlock request, which is a request for unlocking (removal of protection against erasing) of object data stored in a storage medium. Further, the information item No. **11** is reserved for future extension.

When the transformation equipment **71** receives the control information as above, the control information extraction circuit **71***e* extracts the control information, and supplies the control information to the transformation circuit **71***d*. The transformation circuit **71***d* transforms the data (e.g., image data) into SONET frames. At this time, the transformation circuit **71***d* inserts the control information supplied from the control information extraction circuit **71***e*, in predetermined fields of POHs in virtual tributaries which contain the data.

FIG. **7** shows the fields (bytes) in a POH in a virtual tributary. The control information extraction circuit **71***e* inserts the data ID (the information item No. **6**) of 4 bits and the data amount information (the information item No. **7**) of 4 bits in the J**1** byte **150** in the POH, the data storage request (the information item No. **1**) of 2 bits in the F**2** byte **154** in the POH, the source information (the information item No. **10**) of 1 byte in the Z**3** byte **156** in the POH, and the destination information (the information item No. **9**) of 1 byte in the Z**4** byte **157** in the POH.

The SONET frames generated as above are converted into optical signals in the output port **71***f*, and transmitted to the SONET transmission equipment **72**. The SONET transmission equipment **72** cross-connects the optical signals according to the control information, and transfers the optical signals to the SONET transmission equipment **73**, which is indicated in the control information as the destination. When the SONET transmission equipment **73** receives the optical signals, the optical signals are converted into electric signals, and are then supplied to an input buffer in the SONET transmission equipment **73** (e.g., input buffer **100** illustrated in FIG. **5**). For example, the input buffer **100** temporarily stores virtual tributaries of the received SONET frames, and supplies the temporarily stored virtual tributaries to the POH termination unit **104**. The POH termination unit **104** extracts the POHs including the control information from the virtual tributaries supplied from the input buffer **100**, under control of the control information extraction unit **108**, and supplies the extracted POHs to the control information extraction unit **108**. The control information extraction unit **108** receives the POHs extracted by the POH termination unit **104**, extracts the control information from the POHs, and supplies the control information to the data storage control unit **111**.

In this example, the data storage request is included in the control information. Therefore, the data storage control unit **111** controls the path switch unit **109** so that the data (e.g., image data) supplied from the POH termination unit **104** is supplied to the hard disk unit **110** and stored in an area of the hard disk. At this time, the data ID, the data amount information, and storage area information which indicates the area in which the data is stored and registered so that the data ID, the data amount information, and the storage area information are associated with each other.

Thus, the data stored in the contents server **70** can be transferred to the SONET transmission equipment **73** and stored in the hard disk unit **110** in the SONET transmission equipment **73**.

Next, the operations of the data transmission system of FIG. **2** in response to a request for download of data which is sent from a client are explained below.

When the client **77** sends to the contents server **70** a request for download of data (e.g., image data), the request is transferred to the controller **112** in the SONET transmission equipment **72**. When the controller **112** in the SONET transmission equipment **72** receives the request, the controller **112** generates a virtual tributary addressed to the SONET transmission equipment **73**, and inserts a data ID of data to be read out and data amount information in the J**1** byte **150**, a data readout request in the F**2** byte **154**, source information in the Z**3** byte **156**, and destination information in the Z**4** byte **157**, in the POH of the virtual tributary. Then, the SONET transmission equipment **72** transmits a SONET frame containing the virtual tributary to the SONET transmission equipment **73**.

When the SONET transmission equipment **73** receives the SONET frame, the virtual tributary is supplied to, for example, the POH termination unit **104** through the input buffer **100**. The POH termination unit **104** extracts the POH including the control information from the virtual tributary supplied from the input buffer **100**, under control of the control information extraction unit **108**, and supplies the extracted POH to the control information extraction unit **108**. The control information extraction unit **108** receives the POH extracted by the POH termination unit **104**, extracts the control information from the POH, and supplies the control information to the data storage control unit **111**.

Then, the data storage control unit **111** detects the data readout request and the data ID included in the control infor-

mation, and controls the hard disk unit **110** so that the data corresponding to the data ID is read out from the hard disk unit **110**, and also controls the path selection unit **113** so that the path selection unit **113** selects the data read out from the hard disk unit **110**. In addition, the path selection unit **113** supplies destination information (the information item No. **9**) to the control information insertion unit **118**. Thus, the data read out from the hard disk unit **110** is selected by the path selection unit **113**, and supplied to, for example, the POH insertion unit **114**. On the other hand, the POH insertion unit **114** inserts POHs in virtual tributaries containing the data read out from the hard disk unit **110** and selected by the path selection unit **113**, under control of the control information insertion unit **118**, where the destination information is inserted in the *Z*4 byte **157** in each POH. Then, the virtual tributaries are supplied to, for example, the framer **119**, which produces SONET frames containing the virtual tributaries output from the POH insertion unit **114**. The E/O conversion unit **123** generates an optical signal conveying the SONET frames produced by the framer **119**, by electrical-to-optical conversion.

Thus, the optical signal generated as above is transmitted from the SONET transmission equipment **73** to the transformation equipment **76**, and received by the transformation equipment **76** through, for example, the input port **76***a*. The control information extraction circuit **76***c* in the transformation equipment **76** extracts the control information included in the POH in each virtual tributary, and supplies the POH to the transformation circuit **76***b*. The transformation circuit **76***b* transforms the received SONET frames into IP packets. At this time, the destination information included in the POHs in the received SONET frames is inserted in the headers of the IP packets. Then, the IP packets are supplied to the output port **76***d* which is connected to the client **77**, and transmitted to the client **77**. At this time, the transmission rate can be arbitrarily determined according to the transmission line between the transformation equipment **76** and the client **77**.

Thus, the data stored in the hard disk unit **110** can be read out, and transmitted to the client **77**. When a request for readout of data is sent from the client **78** or **79** to the contents server **70**, the data can be read out and transmitted to the client **78** or **79** in a similar manner. Further, when the multicast technique is used, identical data can be concurrently transmitted to the clients **77** to **79**.

As described above, data supplied from the contents server **70** is temporarily stored in the hard disk unit **110** in the SONET transmission equipment **73**, and is thereafter transmitted to a client in response to a request from the client. Therefore, the transmission lines from the contents server **70** to the SONET transmission equipment **73** are not used during the transmission of data from the SONET transmission equipment **73** to the client. Thus, the data can be transmitted from the SONET transmission equipment **73** to the client without affecting the traffic in the transmission lines from the contents server **70** to the SONET transmission equipment **73**.

In addition, the data can be transmitted from the SONET transmission equipment **73** to the client at a transmission rate of the transmission line between the SONET transmission equipment **73** and the client. That is, the data can be transmitted to the client at a transmission rate which is optimum for the client.

When data stored in the hard disk unit **110** becomes unnecessary, the information provider sends to the transformation equipment **71** a request for erasing of the data. When the transformation equipment **71** receives the request for erasing, the transformation equipment **71** inserts a data erasing request in the F**2** byte **154** and a data ID of the data and data amount information in the J**1** byte **150**, in a POH, and sends a SONET frame containing the POH to the SONET transmission equipment **73** through the SONET transmission equipment **72**. Then, the SONET transmission equipment **73** detects the data erasing request, the data ID, and the data amount information, and erases the data in the hard disk unit **110**.

On the other hand, it is possible to lock data stored in the hard disk unit **110** so that the data stored in the hard disk unit **110** is protected against unintended erasing of the data. In order to realize the protected against erasing, the transformation equipment **71** inserts a data lock request in the F**2** byte **154** and a data ID of the data and data amount information in the J**1** byte **150**, in a POH, and sends a SONET frame containing the POH to the SONET transmission equipment **73** through the SONET transmission equipment **72**. Then, the SONET transmission equipment **73** detects the data lock request, the data ID, and the data amount information, and locks the data in the hard disk unit **110**.

Further, it is possible to unlock (i.e., remove protection against erasing of) data stored in the hard disk unit **110**. In order to unlock data, the transformation equipment **71** inserts a data unlock request in the F**2** byte **154** and a data ID of the data and data amount information in the J**1** byte **150**, in a POH, and sends a SONET frame containing the POH to the SONET transmission equipment **73** through the SONET transmission equipment **72**. Then, the SONET transmission equipment **73** detects the data unlock request, the data ID, and the data amount information, and unlocks the data in the hard disk unit **110**.

(5) Operation Flows

The operations of the data transmission system of FIG. **2** can be realized in accordance with the following operation flows of the transformation equipment **71**, the SONET transmission equipment **72**, and the SONET transmission equipment **73**, which are explained below with reference to FIGS. **8** to **15**.

FIG. **8** is a flow diagram indicating an example of a sequence of operations performed by the transformation equipment **71**.

In step S**10**, the control information extraction circuit **71***e* determines whether or not the SONET transmission equipment **72** receive a data storage request from the contents server **70**. When yes is determined in step S**10**, the operation goes to step S**11**. When no is determined in step S**10**, the sequence of FIG. **8** is completed.

In step S**11**, the transformation circuit **71***d* acquires data which is requested to be stored in the hard disk unit **110**, from the input port **71***b*.

In step S**12**, the transformation circuit **71***d* inserts in a POH control information supplied from the control information extraction circuit **71***e*.

In step S**13**, the transformation circuit **71***d* transmits the data with the POH through the predetermined output port **71***f*.

FIG. **9** is a flow diagram indicating an example of a sequence of operations performed by the SONET transmission equipment **72**.

In step S**20**, the control information extraction unit **108** extracts control information from a POH in a received SONET frame, refers to the control information, and determines whether or not the control information includes storage control information (i.e., one of a data storage request, a data readout request, a data erasing request, a data lock request, and a data unlock request). When yes is determined in step S**20**, the operation goes to step S**21**. When no is determined in step S**20**, the operation goes to step S**22**.

In step S21, the controller 112 controls the control information insertion unit 118 so that the control information insertion unit 118 inserts the extracted control information in a POH, and a SONET frame including the POH is transmitted to a destination of the request included in the control information.

In step S22, the controller 112 determines whether or not the SONET transmission equipment 72 has received the SONET frame through a predetermined input port. When yes is determined in step S22, the operation goes to step S24. When no is determined in step S22, the operation goes to step S23.

In step S23, the controller 112 executes the normal SONET frame processing.

In step S24, the control information extraction unit 108 extracts from the extracted control information necessary information including destination information.

In step S25, the controller 112 controls the path switch unit 109 and the path selection unit 113 based on the destination information, and controls the corresponding input buffer so that data portions of SONET frame stored in the input buffer are supplied to the path switch unit 109 through the corresponding POH termination unit.

In step S26, the controller 112 controls the control information insertion unit 118 so that control information is inserted in a POH.

In step S27, the corresponding framer produce a SONET frame containing the data portions output from the corresponding POH insertion unit.

In step S28, the corresponding E/O conversion unit generates an optical signal conveying the SONET frame produced by the framer, by electrical-to-optical conversion, and transmits the optical signal.

FIG. 10 is a flow diagram indicating an example of a sequence of operations performed by the SONET transmission equipment 73.

In step S40, the SONET transmission equipment 73 receives a SONET frame, and virtual tributaries contained in the SONET frame are input into one of the input buffers.

In step S41, the control information extraction unit 108 extracts control information from a POH in each of the virtual tributaries.

In step S42, the control information extraction unit 108 determines whether or not the control information extracted in step S41 includes storage control information (i.e., one of a data storage request, a data readout request, a data erasing request, a data lock request, and a data unlock request). When yes is determined in step S42, the operation goes to step S45. When no is determined in step S42, the operation goes to step S43.

In step S43, the controller 112 executes the normal SONET frame processing.

In step S44, the corresponding E/O conversion unit transmits a SONET frame produced by the normal SONET frame processing in step S43.

In step S45, the data storage control unit 111 determines whether or not the storage control information extracted by the control information extraction unit 108 is a data storage request. When yes is determined in step S45, the operation goes to step S46. When no is determined in step S45, the operation goes to step S47.

In step S46, the data storage control unit 111 executes data storage processing, which is explained later.

In step S47, the data storage control unit 111 determines whether or not the storage control information extracted by the control information extraction unit 108 is a data readout request. When yes is determined in step S47, the operation goes to step S48. When no is determined in step S47, the operation goes to step S49.

In step S48, the data storage control unit 111 executes data readout processing, which is explained later.

In step S49, the data storage control unit 111 determines whether or not the storage control information extracted by the control information extraction unit 108 is a data erasing request. When yes is determined in step S49, the operation goes to step S50. When no is determined in step S49, the operation goes to step S51.

In step S50, the data storage control unit 111 executes data erasing processing, which is explained later.

In step S51, the data storage control unit 111 determines whether or not the storage control information extracted by the control information extraction unit 108 is a data lock request. When yes is determined in step S51, the operation goes to step S52. When no is determined in step S51, the operation goes to step S53.

In step S52, the data storage control unit 111 executes data lock processing, which is explained later.

In step S53, the data storage control unit 111 determines whether or not the storage control information extracted by the control information extraction unit 108 is a data unlock request. When yes is determined in step S53, the operation goes to step S54. When no is determined in step S53, the sequence of FIG. 10 is completed.

In step S54, the data storage control unit 111 executes data unlock processing, which is explained later.

FIG. 11 is a flow diagram indicating details of the data storage processing in step S46 in FIG. 10.

In step S70, the data storage control unit 111 controls the path switch unit 109 so that the corresponding path in the path switch unit 109 is switched and data contained in the virtual tributary is supplied to the hard disk unit 110.

In step S71, the hard disk unit 110 stores the data supplied through the path switch unit 109.

FIG. 12 is a flow diagram indicating details of the data readout processing in step S48 in FIG. 10.

In step S90, the data storage control unit 111 reads out from the hard disk unit 110 data which is designated by the control information.

In step S91, the data storage control unit 111 controls the path selection unit 113 so as to supply the data read out from the hard disk unit 110, to one of the POH insertion units corresponding to source information included in the control information. Then, the the POH insertion unit inserts control information in a POH in each virtual tributary.

In step S92, the framer corresponding to the POH insertion unit executes processing for generating a SONET frame which contains the virtual tributary.

In step S93, the E/O conversion unit corresponding to the above framer generates an optical signal conveying the SONET frame produced by the framer, by electrical-to-optical conversion, and transmits the optical signal.

FIG. 13 is a flow diagram indicating details of the data erasing processing in step S50 in FIG. 10.

In step S110, the data storage control unit 111 searches the hard disk unit 110, and determines whether or not data corresponding to a data ID included in the control information is locked. When yes is determined in step S110, the operation goes to step S112. When no is determined in step S110, the operation goes to step S111.

In step S111, the data storage control unit 111 erases the data in the hard disk unit 110.

In step S112, the data storage control unit 111 executes exception processing since the SONET transmission equipment 73 is requested to erase the locked data.

FIG. 14 is a flow diagram indicating details of the data lock processing in step S52 in FIG. 10.

In step S130, the data storage control unit 111 searches the hard disk unit 110, and determines whether or not data corresponding to a data ID included in the control information is locked. When yes is determined in step S130, the operation goes to step S132. When no is determined in step S130, the operation goes to step S131.

In step S131, the data storage control unit 111 locks the data in the hard disk unit 110 so that the data cannot be erased. For example, in a typical storage system, each data item is locked and unlocked by setting a predetermined bit in a data management table in a hard disk unit to ON or OFF, respectively. That is, the data can be locked by setting the predetermined bit to ON.

In step S132, the data storage control unit 111 executes exception processing since the SONET transmission equipment 73 is requested to lock the already locked data.

FIG. 15 is a flow diagram indicating details of the data unlock processing in step S54 in FIG. 10.

In step S150, the data storage control unit 111 searches the hard disk unit 110, and determines whether or not data corresponding to a data ID included in the control information is locked. When yes is determined in step S150, the operation goes to step S152. When no is determined in step S150, the operation goes to step S151.

In step S151, the data storage control unit 111 unlocks the data in the hard disk unit 110 so that the data can be erased.

In step S152, the data storage control unit 111 executes exception processing since the SONET transmission equipment 73 is requested to unlock the already unlocked data.

(6) Other Embodiments

FIG. 16 is a diagram illustrating an outline of a construction of a SONET transmission equipment used in the second embodiment of the present invention. In FIG. 16, reference numeral 170 denotes a first interface module, 171 denotes a switch module, and 172 denotes a second interface module.

The first interface module 170 in FIG. 16 contains a TDM demultiplexing unit 170*a*, which receives SONET frames, and demultiplexes the SONET frames into virtual tributaries and other overhead information. In addition, although not shown in FIG. 16, the first interface module 170 contains the input buffers 100 to 103, the POH termination units 104 to 107, and the control information extraction unit 108 in FIG. 5. The switch module 171 in FIG. 16 contains the path switch unit 109, the data storage control unit 111, the controller 112, and the path selection unit 113 in FIG. 5. The second interface module 172 in FIG. 16 contains the POH insertion units 114 to 117, the control information insertion unit 118, the framers 119 to 122, and the E/O conversion units 123 to 126 in FIG. 5. In addition, the second interface module 172 includes a plurality of data storage units 172*a* to 172*d*, which are provided corresponding to the plurality of SONET transmission lines, respectively, instead of the common hard disk unit 110 in FIG. 5. The SONET transmission equipment having the construction of FIG. 16 can achieve the substantially the same functions as those of the SONET transmission equipment of FIG. 5.

FIG. 17 is a diagram illustrating an outline of a construction of a SONET transmission equipment used in the third embodiment of the present invention. In FIG. 17, reference numeral 180 denotes a first interface module, 181 denotes a switch module, and 182 denotes a second interface module.

The first interface module 180 in FIG. 17 contains a TDM demultiplexing unit 180*e*, which receives SONET frames, and demultiplexes the SONET frames into virtual tributaries and other overhead information. In addition, although not shown in FIG. 17, the first interface module 180 in FIG. 17 contains the input buffers 100 to 103, the POH termination units 104 to 107, and the control information extraction unit 108 in FIG. 5. The switch module 181 in FIG. 17 contains the path switch unit 109, the data storage control unit 111, the controller 112, and the path selection unit 113 in FIG. 5. The second interface module 182 in FIG. 17 contains the POH insertion units 114 to 117, the control information insertion unit 118, the framers 119 to 122, and the E/O conversion units 123 to 126 in FIG. 5. In addition, the first interface module 180 includes a plurality of data storage units 180*a* to 180*d*, which are provided corresponding to the plurality of SONET transmission lines, respectively, instead of the common hard disk unit 110 in FIG. 5. The SONET transmission equipment having the construction of FIG. 17 can also achieve the substantially the same functions as those of the SONET transmission equipment of FIG. 5.

FIG. 18 is a diagram illustrating an outline of a construction of a SONET transmission equipment used in the fourth embodiment of the present invention. In FIG. 18, reference numeral 190 denotes a first interface module, 191 denotes a switch module, and 192 denotes a second interface module.

The first interface module 190 in FIG. 18 contains the input buffers 100 to 103, the POH termination units 104 to 107, and the control information extraction unit 108 in FIG. 5. The switch module 191 in FIG. 18 contains the path switch unit 109, the data storage control unit 111, the controller 112, and the path selection unit 113 in FIG. 5. The second interface module 192 in FIG. 18 contains the POH insertion units 114 to 117, the control information insertion unit 118, the framers 119 to 122, and the E/O conversion units 123 to 126 in FIG. 5. In addition, the switch module 191 includes a data storage unit 191*a* and a switch unit 191*b*. The switch unit 191*b* corresponds to the path switch unit 109 and the path selection unit 113 in FIG. 5.

Although the data storage unit 191*a* is provided corresponding to the hard disk unit 110 in FIG. 5, data are exchanged between the data storage unit 191*a* and the switch unit 191*b* as follows. When the SONET transmission equipment receives a data storage request, received data is supplied to the data storage unit 191*a* through the first interface module 190 and the switch module 191, and stored in the data storage unit 191*a*. In addition, when the SONET transmission equipment receives a data readout request, data stored in the data storage unit 191*a* is read out from the data storage unit 191*a*, and supplied to the input side of the switch unit 191*b*. The SONET transmission equipment having the construction of FIG. 18 can also achieve the substantially the same functions as those of the SONET transmission equipment of FIG. 5.

FIG. 19 is a diagram illustrating an outline of a construction of a SONET transmission equipment used in the fifth embodiment of the present invention. In FIG. 19, reference numeral 200 denotes a first interface module, 201 denotes a switch module, 202 denotes a data storage module, and 203 denotes a second interface module. The SONET transmission equipment of FIG. 19 is different from the SONET transmission equipment of FIG. 18 in that the data storage unit is provided in a separate module 202 from the switch module 201. The SONET transmission equipment having the construction of FIG. 19 can also achieve the substantially the same functions as those of the SONET transmission equipment of FIG. 5.

(7) Other Matters

(i) Although the above embodiments are explained based on the SONET systems, substantially the same constructions can also be realized based on the SDH systems.

(ii) The foregoing is considered as illustrative only of the principles of the present invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and applications shown and described, and accordingly, all suitable modifications and equivalents may be regarded as falling within the scope of the invention in the appended claims and their equivalents.

(iii) All of the contents of the Japanese patent application, No.2001-344277 are incorporated into this specification by reference.

What is claimed is:

1. Data transmission equipment for use as a constituent of a multiplex transmission network, comprising:

a reception unit which receives data;

a control information extraction unit which extracts control information from said data received by the reception unit;

a data acquisition unit which determines whether or not said control information includes a request for storage of said data, and acquires the data when said control information includes the request for storage of the data;

a data storage unit which stores the data acquired by the data acquisition unit;

a data erasing unit which determines whether or not said control information includes a request for erasing of said data stored in said data storage unit, and erases the data from the data storage unit when said control information includes the request for erasing of the data; and

a data lock unit which determines whether or not said control information includes a request for locking said data stored in said data storage unit, and locks the data stored in said storage unit so that said stored data is protected against unintended erasing when said control information includes the request for locking the data.

2. The data transmission equipment according to claim **1**, further comprising,

a data readout unit which determines whether or not said control information includes a request for readout of first data and second data stored in said data storage unit, and reads out the first data and the second data from the data storage unit when said control information includes the request for readout of the first data and the second data, and

a transmission unit which transmits said first data and said second data to a destination.

3. The data transmission equipment according to claim **2**, wherein said reception unit receives said first data at a first transmission rate, said transmission unit transmits said second data at a second transmission rate, and the first and second transmission rates can be determined independently of each other.

4. The data transmission equipment according to claim **2**, wherein said transmission unit transmits said second data to a plurality of destinations.

5. The data transmission equipment according to claim **2**, further comprising a control information insertion unit which inserts control information in said second data transmitted by the transmission unit.

6. The data transmission equipment according to claim **1**, wherein said data storage unit is arranged in said reception unit.

7. The data transmission equipment according to claim **1**, wherein said data storage unit is arranged in said transmission unit.

8. The data transmission equipment according to claim **1**, further comprising a switch unit which cross-connects transmission lines, and said data storage unit is arranged in the switch unit.

9. The data transmission equipment according to claim **1**, wherein said reception unit receives said first data in accordance with one of SONET and SDH technologies.

10. The data transmission equipment according to claim **1**, wherein said transmission unit transmits said second data in accordance with one of SONET and SDH technologies.

11. A method for transmitting data from a first network node to a second network node through an interlinking network including a plurality of data transmission equipment units, comprising the steps of:

(a) transmitting said data together with a storage request for storage of the data and a lock request for locking the stored data in one of the plurality of data transmission equipment units, from said first network node to the one of the plurality of data transmission equipment units;

(b) receiving said data, said storage request, and said lock request by said one of the plurality of data transmission equipment units;

(c) storing said data in a storage unit provided in said one of the plurality of data transmission equipment units, based on said storage request;

(d) transmitting a readout request for said data, from said second network node to the one of the plurality of data transmission equipment units;

(e) receiving said readout request by said one of the plurality of data transmission equipment units;

(f) reading out said data from said storage unit, based on said readout request; and

(g) transmitting said data from said one of the plurality of data transmission equipment units to said second network node;

(h) locking said data stored in said storage unit so that said stored data is protected against unintended erasing, based on said lock request;

wherein said step (d) comprises the substeps of:

(d1) transmitting said readout request from said second network node to said first network node; and

(d2) transferring said readout request from said first network node to said one of the plurality of data transmission equipment units.

12. The method according to claim **11**, wherein in said step (a), said data, said storage request, and said lock request are multiplexed.

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